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Oliver Heinonen

The development of a waterway project risk management framework

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Summary

The success of a waterway construction or maintenance project is strongly dependent on the management of risk. Striving for better results in their projects, the Finnish Transport Agency (FTA) had recognized the need to improve the resources, tools and guidelines available for the risk management of waterway projects. However, the target is ambiguous, as the optimal approach to risk management cannot be explicitly defined. There are no objective means available for determining an optimal approach to risk management, and there are no risk management standards which would explicitly discuss projects conducted in the context of a larger organization. Instead, various international and national standards and guidelines exist for risk management, each focusing on their own subject matter. Therefore, the first question one must ask in order to develop the practice of risk management is how does one determine which standard or guideline is the most valid in a given context?

In this thesis, a literature review, several expert interviews, and an expert survey were used to gather information about the theory and the current state of waterway project risk management in Finland. This was supported by a limited amount of information from Sweden and Denmark. The FTA waterway risk management framework, which includes the guidelines, tools, human resources, policies, processes and commitment available for managing risk, was evaluated utilizing the ISO 31004:2013 technical report for the implementation of the ISO 31000:2009 standard for risk management. This evaluation result was used to identify the possibilities of developing the risk management framework. Based on these results, the following risk management tools and processes were developed:

- three risk management processes tied to the structures of waterway projects,
- three hazard checklists,
- the inclusion of opportunity management,
- the enhancement of the risk analysis process, and
- a model for the establishment of the context of the risk management process

The tools and processes were validated through case studies and user group testing, based on which the feasibility of the enhancements was assessed. Finally, recommendations were made for the development of the waterway project risk management framework

Oliver Heinonen: Vesiväylähankkeiden riskienhallinnan puitteiden kehitystyö. Liikennevirasto, hankesuunnitteluosasto. Helsinki 2016. Opinnäytetyö 13/2016. 73 sivua ja 6 liitettä. ISSN 2343-1741, ISBN 978-952-317-312-5.

Avainsanat: riskienhallinta, vesiväylähanke, rakentaminen, kunnossapito

Tiivistelmä

Vesiväylien rakentamis- ja kunnossapidon projektien onnistuminen riippuu merkittävästi riskienhallinnasta. Tavoitteenaan edistää riskienhallintaa vesiväyläprojekteissa, Liikennevirasto oli havainnut tarpeen kehittää vesiväylähankkeita palvelevia riskienhallinnan resursseja, työkaluja ja ohjeita. Ei kuitenkaan ole täysin selvää, millaiseen riskienhallintaan tulisi pyrkiä. Ei ole olemassa objektiivista tapaa määritellä optimaalinen lähestymistapa riskienhallintaan, eikä yksikään riskienhallinnan standardi suoraan käsittele projekteja, jotka toteutetaan osana laajempaa organisaatiota. Vaikka useampi kansainvälinen ja kansallinen standardi ja ohje käsittelevät riskienhallintaa, ne huomioivat vain oman erikoisalueensa. Ensimmäinen kysymys vesiväyläprojektien riskienhallinnan kehittämisessä kuuluikin, kuinka määritellään, mikä riskienhallinnan standardi tai ohje soveltuu tarkoitukseen parhaiten.

Diplomityössä kerättiin ensin tietoa vesiväyläprojektien riskienhallintaan sovellettavasta teoriasta sekä tämänhetkisistä käytännöistä Suomessa, Ruotsissa sekä Tanskassa. Tiedon hankinnan menetelminä käytettiin kirjallisuuskatsausta, asiantuntijahaastatteluita sekä asiantuntijoille suunnattua kyselyä. Liikenneviraston vesiväylähankkeiden riskienhallinnan puitteita, eli mm. ohjeita, työkaluja, resursseja, politiikkaa, prosesseja ja sitoutumista arvioitiin käyttäen riskienhallinnan standardin ISO 31000:2009 jalkauttamisohjetta ISO 31004:2013. Arvioinnin perusteella tunnistettiin ensin riskienhallinnan puitteiden kehitysmahdollisuuksia, ja sen perusteella kehitettiin seuraavat riskienhallinnan työkalut ja prosessit:

- kolme vesiväylähankkeiden läpivientiin sidottua riskienhallinnan prosessia,
- kolme vaarojen tarkistuslistaa,
- mahdollisuuksien hallinnan sisällyttäminen riskienhallinnan prosessiin,
- riskianalyysin parannuksia, sekä
- malli riskienhallinnan toimintaympäristön määrittelylle.

Kehitettyjen työkalujen ja prosessien toimivuutta tarkasteltiin tapaustutkimusten ja käyttäjäryhmätestauksen avulla, joiden perustella arvioitiin työkalujen ja prosessien hyödyllisyyttä ja toimivuutta. Lopuksi tehtiin suosituksia vesiväyläprojektien riskienhallinnan puitteiden kehittämiselle.

Oliver Heinonen: Utveckling av ramverk för riskhantering vid farledsprojekt. Trafikverket, projektplaneringsavdelningen. Helsingfors 2016. Lärdomsprov 13/2016. 73 sidor och 6 bilagor. ISSN 2343-1741, ISBN 978-952-317-312-5.

Sammandrag

Hur projekt för byggande och underhåll av farleder lyckas beror i väsentlig grad på riskhanteringen. I syfte att främja riskhanteringen vid farledsprojekt hade Trafikverket upptäckt att det finns ett behov att utveckla resurser, verktyg och anvisningar som betjänar riskhanteringen vid dessa projekt. Det är ändå inte helt klart vilken typ av riskhantering man borde eftersträva. Det finns inget objektivt sätt att definiera en optimal infallsvinkel på riskhantering, och ingen standard för riskhantering handlar direkt om projekt som genomförs som en del av en större organisation. Trots att flera internationella och nationella standarder och anvisningar behandlar riskhantering, fokuserar dessa endast på sina egna specialområden. Den första frågan i utvecklingen av riskhanteringen vid farledsprojekt var således hur man definierar vilken riskhanteringsstandard eller anvisning som är bäst lämpad för ändamålet.

I diplomarbetet samlade man först in information om en teori som kan tillämpas på riskhantering vid farledsprojekt samt information om praxis som för närvarande tillämpas i Finland, Sverige och Danmark. Som metoder för inhämtning av information användes litteraturöversikt, intervjuer med experter samt en förfrågan som riktades till experter. Ramverk för riskhantering vid Trafikverkets farledsprojekt, dvs. bl.a. anvisningar, verktyg, resurser, politik, processer och engagemang bedömdes via standarden för riskhantering ISO 31000:2009 och anvisningen ISO 31004:2013. Utifrån bedömningen identifierades först möjligheterna att utveckla ramverket för riskhantering och på basis av detta utvecklades följande verktyg och processer för riskhantering:

- tre riskhanteringsprocesser bundna till genomdrivande av farledsprojekt
- tre checklistor för faror
- inkludera hanteringen av möjligheter i riskhanteringsprocessen
- förbättringar i riskanalysen
- modell för definition av riskhanteringsmiljön.

Funktionen hos de utvecklade verktygen och processerna kontrollerades genom fallstudier och ett test av en användargrupp. Utifrån dessa bedömde man verktygens och processernas nytta och funktion. Till sist gav man rekommendationer för utveckling av ramverk för riskhantering vid farledsprojekt.

Foreword

The management of risk has a major impact to the successfulness of waterway projects, independent of whether the risks are managed consciously – or unconsciously. This thesis aims to clarify and develop the risk management practices in the waterway construction and maintenance projects of the Finnish Transport Agency.

This thesis was written and the corresponding research conducted by Oliver Heinonen from Aalto University. The thesis work was steered and advised by Dr Arja Toola, Tero Sikiö and Marko Reilimo from the Finnish Transport Agency, and by Outi Lehti from Ramboll CM Ltd. Their academic counterparts were the supervisor of this work, Professor Terhi Pellinen, and advisor Dr Jakub Montewka from Aalto University.

Helsinki, September 2016

Finnish Transport Agency
Project Planning Department

Table of Contents

Abbreviations and terms

ALARP — As Low As Reasonably Practicable – is used to describe a level of risk which is optimal in comparison with the cost of the further potential treatment or mitigating actions.

ERM — Enterprise Risk Management – consists of active and intrusive processes that (1) are capable of challenging existing assumptions about the world within and outside the organization; (2) communicate risk information with the use of distinct tools (such as risk maps, stress tests, and scenarios); (3) collectively address gaps in the control of risks that other control functions (such as internal audit and other boundary controls) leave unaddressed; and, in doing so, (4) complement – but do not displace – existing management control practices. (definition by Mikes & Kaplan 2014).

Essential tools of RM

(FI: Riskienhallinnan perustyökalut) – Comprises of the following four tools,): SWOT-analysis, risk map, risk management form, and risk matrix. (Liikennevirasto 2015).

FTA — Finnish Transport Agency (FI: Liikennevirasto)

ISO — International Organization for Standardization

Project — A project is a temporary endeavour to create a unique product, service, or result. The temporary nature of projects indicates that a project has a definite beginning and end. The end is reached when the projects objectives have been achieved or when the project is terminated because its objectives will not or cannot be met, or the when the need for the project no longer exists. (PMI 2013:3).

Risk — An unexpected negative or positive situation or event, which prevents or disturbs the realization of objectives, process or action, or provides new possibilities for achieving them. Risk has a magnitude, which is quantified based on the probability and the severity of consequences. This is the definition is by the FTA (Liikennevirasto 2015) – see also the definition of ISO 31000:2009 in Section 2.4.

RA — Risk assessment is a systematic process consisting of risk identification, risk analysis and risk evaluation. (ISO 31000:2009 and Liikennevirasto 2015).

RM — Risk management is a systematic process consisting of establishing the risk management context, risk assessment, risk treatment, monitoring and reviewing, and communication and consulting. (ISO 31000:2009 and Liikennevirasto 2015).

RM framework	The set of components that provide the foundations and organizational arrangements for designing, implementing, monitoring, reviewing and continually improving risk management throughout the organization, see also Section 2.4. (ISO 31000:2009).
RM plan	Scheme within the risk management framework specifying the approach, the management components and resources to be applied to the management of risk
RM approach	The manner in which a risk management problem is solved.

1 Introduction

1.1 Research background

A majority of the international freight across the borders of Finland is transported by freight vessels, which navigate the archipelago along specific waterways. These waterways are constructed and maintained by the Finnish Transport Agency (FTA). The construction and maintenance work is divided into individual projects, where private service providers conduct the practical work while the FTA reserves the role of a client. The projects come with different complexities and magnitudes, ranging from the Baltic Sea waterway deepening projects to the replacement of a few navigation marks on a freshwater lake.

These projects face numerous risks, or uncertainties related to the achievement of project objectives. These risks arise, for example, from the ambiguity of the contract and tender documents, or from the lack of knowledge about the time required for dredging work. The responsibility for navigating the field of project risk lies primarily on the client who uses the tender process and contracting to transfer a share of that risk to the service provider. The risks faced in these projects are perhaps best demonstrated through the hazard checklists in the Appendix A6.2 Hazard checklists, and in Liikennevirasto (2012).

The success of a project is more or less dependent on the success of the management of project risk. However, the success of project risk management is determined by a number of factors, most of which exceed the boundaries of single projects in an organization such as the FTA. These factors include e.g. the guidelines, tools, human resources, policies, processes and commitment available for managing risk, which together form a risk management framework. Thus, in order to evaluate or develop the risk management approach in individual waterway projects, one must consider all the factors of the risk management framework.

For the application of risk management to waterway construction and maintenance projects by the FTA, the role of risk management has been to control the environmental, health and safety risk. The FTA's general approach has recently been adapted towards a wider perspective on project risk. Nevertheless, while the guidelines and policy for risk management have been adapted to include financial and schedule risk, the available tools and processes have not. It should be noted, that not all risk management is necessarily good – on the contrary, Hubbard (2008) argues that in some cases bad risk management can lead to worse results than with no risk management at all.

Systematically striving for better results in their projects, the FTA had recognized the need to develop the risk management framework for the use of waterway project risk management. In theory, optimal risk management reduces the amount of risk up to a level, where the means and the cost of reducing the risk matches the benefits of the reduction. However, it is not completely clear, what kind of risk management produces the optimal results in practice. There are no objective means available for determining an optimal approach to risk management, and there are no standards, which would explicitly discuss projects conducted in the context of a larger

organization. Instead, the field spans a number of standards and guidelines for risk management, each focusing on their own subject matter – so, when concerned about waterway construction and maintenance projects inside an organization, should one expect to find the optimal risk management approach in the risk management standard for organizations, enterprises, projects, or perhaps waterway traffic? It appears that the field of risk management is fairly immature, despite – or because of the vast number of standards.

The FTA's current risk management approach for infrastructure projects is based on the risk management standard ISO 31000:2009, although the standard has not been thoroughly implemented. The ISO standard is complemented with a technical report for its implementation, the ISO 31004:2013, which describes a process for the evaluation of the current practice through the comparison of the practice with the standard. This evaluation process was perceived as the necessary tool for understanding the shortcomings and the connections of the current practice.

1.2 Research objectives

The objective of the research was to improve the practice of risk management in waterway projects in Finland, while providing theoretical contribution through the framework of constructive research. In other words, the objectives of the research were to:

1. Analyse and clarify the FTA risk management framework for waterway construction and maintenance projects while suggesting improvements, and
2. Develop risk management constructs (tools and processes) for the application of the improvements in practice.

The constructs were to be designed from the point-of-view of being used by the management of waterway projects. The constructs primarily serve FTA project managers in conducting risk management in their projects, and secondarily the various service providers in these projects.

1.3 Scope and limitations

The scope of this research spans the construction and maintenance of the FTA governed waterways in Finland. Thus, the planning phase of waterways is outside the scope of this work.

The designed risk management constructs focus on the bottom-up, or micro-level ERM approach, describing the risk management manoeuvres conducted by the project management to address local-level risks, as described by Nocco & Stulz (2006). These are described by the FTA (2016) as operational risks.

The scope of the research includes the whole variety of risks a waterway project can be vulnerable to. These include e.g. financial, safety and environmental concerns.

The accountabilities, relationships, and human or financial resources internal to a project were not in the scope of this work. Also the planning of the practical implementation of the risk management constructs in the FTA organization was not included in the scope of this work.

2 Literature review

2.1 Theoretical background of the research

Although this research focuses on the project level of RM in waterway environment, the organization or enterprise perspective is adopted for interpreting the success or failure of the RM in an organization encompassing several projects. In other words, the assumption is made, that the organizational, or enterprise risk management (ERM) approach applies to single projects in a larger organization, and that the micro-level benefits of ERM can be sought for without accounting for the organization-level benefits (as described by Nocco & Stulz 2006).

In order to successfully analyse and develop an ERM framework, a theory, or a basis for that analysis is required. However, as Mikes & Kaplan (2014) and Bromiley et al. (2015) argue, no established theory exists, which would explain the success of one risk management approach over the other in the field of ERM.

To cap the hole, Mikes & Kaplan (2014) propose the contingency theory, which claims that the success of a given ERM practice or "mix" depends on the contingent variables, such as the managed risk types and the industry. In other words, they suggest that risk management will be most effective when it matches the inherent nature and controllability of the different types of risk the organization faces. Mikes & Kaplan propose a "minimum necessary contingency framework" (*Figure 1*) for the basis of practical use of the contingency theory.

In the case of the relatively new and unestablished contingency theory, a "common body of knowledge" describing the best combinations of factors is not readily available. Therefore, to provide a measure for the organizational effectiveness of an ERM approach, Mikes & Kaplan (2014) following Otley (1980) suggest using user satisfaction surveys and managerial perceptions of the ERM function as potential indicators.

Contingency theory suggests that an ERM mix should be divided into its fundamental RM components for its observation and development. This is also the suggested approach for implementing the RM standard ISO 31000:2009; the technical report ISO 31004:2013 suggests the evaluation of an organization's RM practice against the ISO 31000:2009. Thus it is assumed that the implementation process described in ISO 31004:2013 is in line with the contingency theory, and will provide the necessary information for this research to contribute to the knowledge on the practical application of the theory.

The choice of using the ISO standard family as the basis for the approach in this research was influenced by the FTA's use of the RM standard ISO 31000:2009 as the primary reference for both the organization-scale and infrastructure project scale RM guidelines (Liikennevirasto 2015 and 2016d). The implementation level of the ISO 31000:2009 to the FTA waterway project RM practices is analysed in Section 4.3.

Yet it should be noted, that there is no guarantee that the ISO 31000:2009 describes the best RM solution for waterway projects – the ISO 31004:2013 is merely seen here as an adequate practical guideline for facilitating the analysis of the current waterway project RM approach.

Instead, the field of project risk management research could equally well provide adequate tools for waterway project RM – especially when dealing with large, complex projects with multiple organizations, where project successes are clearly linked with higher level of RM implementation (Harvett 2013).

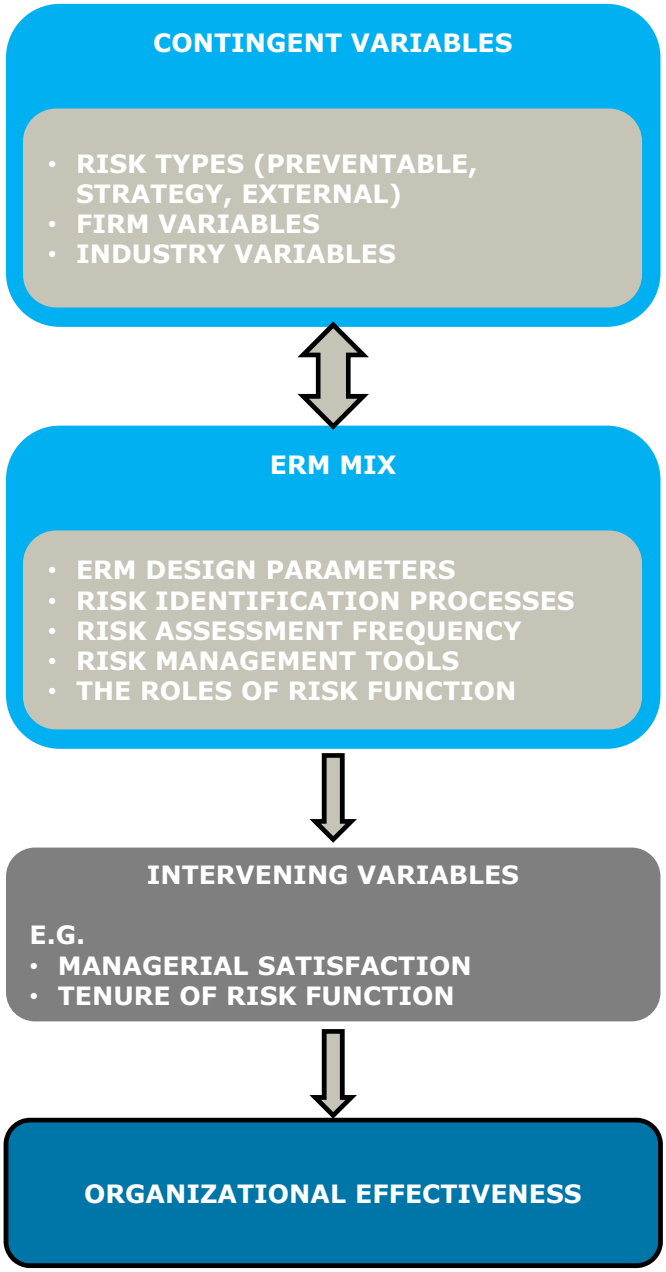


Figure 1: The minimum necessary contingency framework of the contingency theory, adopted from Mikes & Kaplan 2014.

The theoretical connection between ERM and project RM in the context of this thesis is further explored below in Section 2.2.

2.2 A theoretical approach to project RM

As the ERM approach should look at the RM processes from the organizational level, and is thus appropriate for the organization to pursue its collective goals, the actions of the individual waterway project and project risk managers are assumed to more likely reflect the goals of individual projects. Given this assumption, the waterway project risk management framework would need to be able to reflect the environment of individual waterway projects in a way that also assists in the pursuing of organization-level goals.

However, the question of how projects and their subsequent risks should be managed is all but clear. What the scholars (and some of the practitioners) of project management collectively appear to agree on, is that the most functional management approaches reflect the project properties, such as the project complexity, and thus vary between projects (Harvett 2013, Atkinson et al. 2006, and Lehtiranta 2014). This is in line with the contingency theory of ERM (Mikes & Kaplan 2014), and from an organization's management's perspective might call for a similar "common body of knowledge" as the contingency theory.

The PMBOK – the Project Management Body of Knowledge (PMI 2013) – answers the problem from the point-of-view of conventional project management. However, the risk management approach in PMBOK is shallow, and doesn't account for all of the varying properties of project risk. *"Perhaps the conventional common view of project management is essentially to see the project task as a set of processes to ensure a project meets its (predetermined) objectives. Then the whole raison d'etre of project management is to remove (or substantially reduce) uncertainty about meeting specified objectives. However, project management in this sense is a castle built on shifting sands if in practice objectives are unclear, contradictory, or impossible. Many endeavours recognised and 'managed' as projects experience problems for this reason*." (Atkinson et al. 2006).

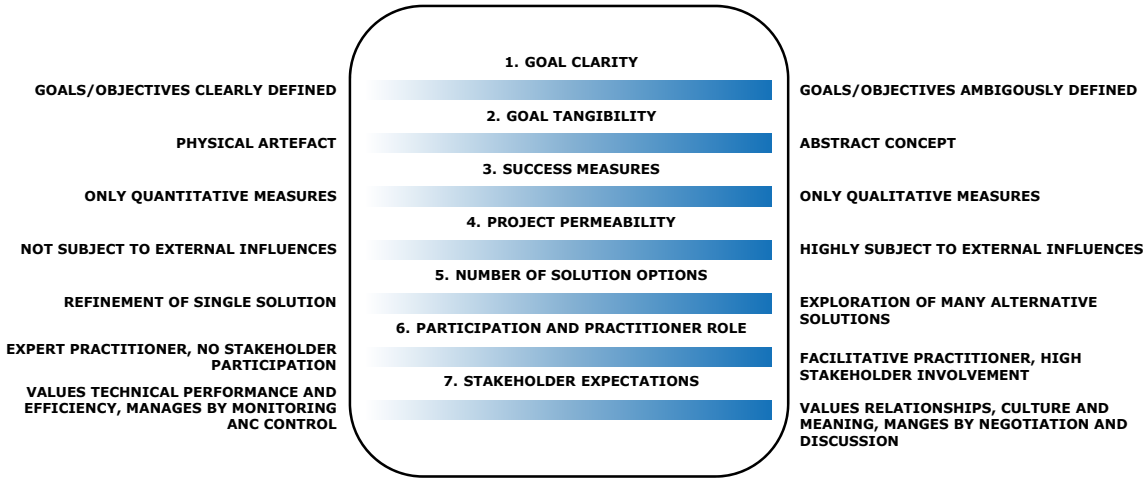


Figure 2: The seven dimensions of project hardness and softness, adapted from Crawford & Pollack (2004:650).

These varying properties include at least the perceived hardness vs. softness of projects, relating to the amount of needed disciplines and the strength of the predefined project objectives (Atkinson et al. 2006, Harvett 2013). Crawford & Pollack (2004:650) describe the seven dimensions of hardness and softness of projects, illustrated in *Figure 2*. Another such property is project complexity, which is explored for example by Harvett (2013).

However, the question of how to choose the correct or best approach for each project's risk management is still left unanswered. This might call for a similar answer as the contingency theory of ERM – a common body of knowledge for project RM approaches, with the ability to differentiate between the variables with significant effect on the approach functionality and effectivity.

2.3 Waterways and waterway projects in Finland

Waterway as a structure

From an engineering point-of-view, a waterway can be described as an underwater 3D-space: a guaranteed water depth delimited from the sides with virtual lines. The places of these lines and a ship's position in relation to them are acknowledged by the navigator based on the on-board navigation system – or, if the technology should fail, the navigator is guided by a map and a compass, using the help of sea-marks placed along the route. On the top of the surface the 3D-space continues as guaranteed space above the route, where the possible bridge structures or power lines keep away. (Liikennevirasto 2013).

The construction process of such waterways is relatively simple compared to e.g. construction of buildings: one measures the concurrent depth of the water inside the given 3D-space, dredges away the extra, and places the sea-marks along the route in accordance to the plans: either as floating buoys anchored to the bottom or as solid structures on ground. Some sea-marks include electronic parts, such as lights and power devices, others reflect radar signals, but most work as simple visual aids with reflective surfaces.

The maintenance works are in principle not much more complicated: one ensures that the seamarks are in a good enough condition to fulfil their task and sees to that the route depths have not shallowed during the flow of time, due to e.g. erosion outside the given 3D-space. Maintenance also includes here the management of registers and the conducting of certain enhancement projects. (Kerkelä 2016).

The freshwater waterways add some complexity with their canals, which are built to connect lakes with each other and the sea, and their locks, which enable ships to transport between lakes with differing elevations. The locks and canals include massive mechanical structures and concrete walls, which call for use and care on a daily basis (Kerkelä 2016), and require deep trenches during the construction phase.

The technical uncertainties in waterway projects arise from the long distances, large vessels, and the water element, the combination giving rise to questions related to weather, safety, and environment.

The Finnish waterway network

The waterways in Finland are classified on a scale of six classes according to their required service level, which again are based on the waterways' importance to transportation. The waterway classes VL1 to VL2 regularly serve freight transportation, while classes VL3 to VL6 include shallower waterways, which serve economically less important transportation. The lengths of the waterways both at sea and in freshwater environments are described in the *Table 1*. The descriptions of the waterway classes can be found in Waterway classification in Finland.

Of the 19 894 km of waterways in Finland (as in 2012), 16 254 km are governed by the FTA. The remaining 3 641 km are under private governance, of which 2 697 km are classified as VL6, the lowest service level waterways. These were delimited outside the scope of this work due to their different form of governance, although there appears to be no reason why the constructs would not work for VL6 waterway projects. (Liikennevirasto 2013).

One feature of the waterway network in Finland is the annual freezing of all of the freshwater routes for several months. Depending on the winter, almost the whole Baltic Sea might freeze as well, which has happened five times during 1958–2008 (Merenkulkulaitos 2008:27).

Table 1: The length (km) of public waterways per waterway class in Finland in 2012. The FTA columns stand for waterways maintained by the FTA, while the "Other" columns stand for waterways maintained by others. Adapted from Liikennevirasto 2013.

Waterway class	Coastal		Freshwater		Total	
	FTA	Other	FTA	Other	FTA	Other
VL1	2 172 km	111 km	0 km	0 km	2 172 km	111 km
VL2	1 023 km	81 km	757 km	8 km	1 780 km	89 km
VL1 - VL2	3 195 km	192 km	757 km	8 km	3 952 km	200 km
VL3	2 642 km	84 km	2 071 km	7 km	4 713 km	91 km
VL4	892 km	68 km	284 km	3 km	1 176 km	71 km
VL5	876 km	565 km	3 077 km	17 km	3 953 km	582 km
VL6	643 km	932 km	1 817 km	1 765 km	2 460 km	2 697 km
VL3- VL6	5 058 km	1 652 km	7 245 km	1 778 km	12 302 km	3 441 km
Total VL1 - VL6	**8 231 km**	**1 848 km**	**8 005 km**	**1 786 km**	**16 254 km**	**3 641 km**

Figure 3: The figure describes the ice circumstances in the Baltic Sea during winters. The middle picture describes the average scope of ice coverage, while on the left is the minimum and on the right the maximum ice coverage in the Baltic Sea. Adopted from Merenkulkulaitos 2008:27.

FTA waterway projects

The FTA waterway projects run mostly on funding from the government budget, while some of the projects receive additional funding from the EU or other public organizations. FTA does not conduct almost any of the practical work itself, but the projects are publicly tendered, and conducted by private companies. In order to provide a functioning market, the work is divided into projects.

The funding for waterway maintenance and small projects is allocated in the FTA budget under waterway maintenance (FI: vesiväylänpito), with the sum of ca. 80 M€ in 2015. (Liikennevirasto 2016c:32–44). Waterway maintenance includes in the taxonomy of the FTA the two separate classes: care and use, and upkeep (Kerkelä 2016).

Care and use contains the daily maintenance tasks, such as using locks and taking care of sea-marks. The work is mostly arranged in five-year projects, and from year 2016 the use and care in Finland is divided into 15 projects, of which four are being tendered in 2016 (Kerkelä 2016).

Upkeep, on the other hand, includes a variety of project types from planning and research to repair works and register management, and the sizes of the projects vary. These are mostly tendered through general agreements. (Kerkelä 2016).

Funding for larger projects is allocated separately from the figure of waterway maintenance. In 2015, two such waterway projects were given separate funding. These included the Rauma harbour waterway deepening project with government participation of 27 M€ (2015-2017) (Liikennevirasto 2016b), and the transfer of the Savonlinna waterway with government participation of 4 M€ in 2015. (Liikennevirasto 2016c:32–44).

While the waterway maintenance projects are mostly managed completely by FTA employees, in larger projects a separate project management consultant is often acquired to take care of the practical management tasks, enabling a thin organisation from the FTA's side.

2.4 Risk concepts

The standard ISO 31000:2009 for risk management defines a number of terms related to risk. There are, however, other academically used definitions as well, and depending on the context, the definition of risk itself can vary substantially. This does not necessarily that mean all the interpretations are equal; there is no guarantee that the definition generally used for a given context is the best one for that very context. (Aven 2012).

The following sections describe some risk concepts as they are found in the literature, and especially in the ISO 31000:2009, to provide the necessary background for interpreting the results of the study.

A definition of RM Framework
A risk management framework defines the approach of an organization for managing risk. ISO 31000:2009 defines a risk management framework as follows:

Risk management framework – set of components that provide the foundations and organizational arrangements for designing, implementing, monitoring, reviewing and continually improving risk management throughout the organization.

- *NOTE 1 The foundations include the policy, objectives, mandate and commitment to manage risk.*

- *NOTE 2 The organizational arrangements include plans, relationships, accountabilities, resources, processes and activities.*

- *NOTE 3 The risk management framework is embedded within the organization's overall strategic and operational policies and practices.*

The success of risk management will depend on the effectiveness of the framework providing the foundations and arrangements that will embed it throughout the organization at all levels. The framework assists in managing risks effectively through the application of the risk management process at varying levels and within specific contexts of the organization. The framework ensures that information about risk derived from the risk management process is adequately reported and used as a basis for decision making and accountability at all relevant organizational levels. (ISO 31000:2009).

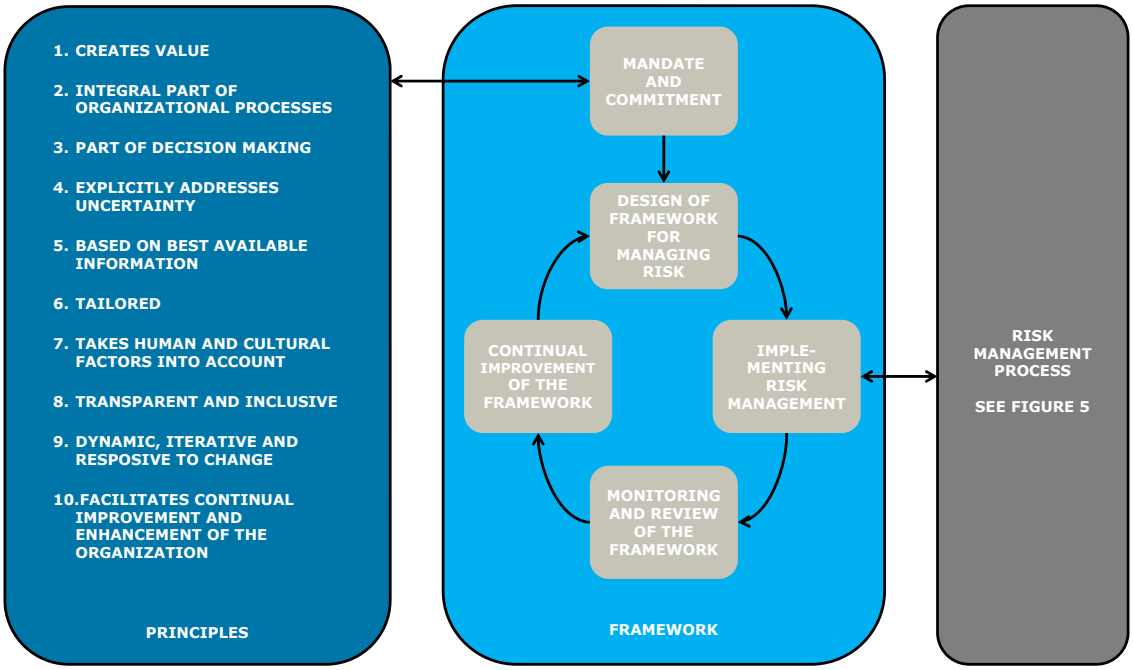


Figure 4: The process and principles of designing and maintaining a risk management framework, adapted from ISO 31000:2009.

Constant monitoring and continual development of a risk management framework are required in order to ensure that risk management is effective and continues to support organizational performance (ISO 31000:2009).

The definition of risk

The starting point of this work, when it came to the definition of risk, was the definition by the FTA (Liikennevirasto 2015), which treats risks as events with probability and consequence:

Risk is defined as an unexpected negative or positive situation or event, which prevents or disturbs the realization of objectives, process or action, or provides new possibilities for achieving them. Risk has a magnitude, which is quantified based on the probability and the severity of consequences.

The origin of the FTA risk definition is the ISO 31000:2009. However, based on one of the authors of the FTA guideline (Liikennevirasto 2015), the definition of risk was altered to provide easier comprehensibility in the practical, project level.

In contrast, ISO 31000:2009 defines risk as follows:

Risk is the effect of uncertainty on objectives.

NOTE 1: An effect is a deviation from the expected – positive and/or negative.

NOTE 2: Objectives can have different aspects (such as financial, health and safety, and environmental goals) and can apply at different levels (such as strategic, organization-wide, project and process).

NOTE 3: Risk is often characterized by reference to potential events and consequences, or a combination of these.

NOTE 4: Risk is often expressed in terms of combination of the consequences of an event (including changes in circumstances) and the associated likelihood of occurrence.

NOTE5: Uncertainty is the state, even partial, of the deficiency of information related to, understanding or knowledge of an event, its consequence, or likelihood.

While the definitions do resemble each other, there are also differences. The practical differences resulting from the changes to the ISO 31000:2009 risk definition should be considered. One noteworthy consequence of the differences is that uncertainty, being omitted in the FTA definition of risk, can more easily go unnoticed in the course of risk management. Rather, the closest match to "uncertainty" is the part "unexpected event or situation" in the FTA definition.

Aven (2012:37) classifies risk definitions into nine categories. One category is the ISO 31000:2009 definition. However, the FTA definition (Liikennevirasto 2015) appears to better fit the following category: "Risk = Probability and scenarios/Consequences/ severity of consequences". Aven quotes four definitions fitting this category, of which the following one is in practice identical to the definition of the FTA:

Risk is equal to the triplet (s_i, p_i, c_i), where s_i is the ith scenario, p_i is the probability of that scenario, and c_i is the consequence of the ith scenario, i = 1,2,…,N; i.e. risk captures: What can happen? How likely is that to happen? If it does happen, what are the consequences? (Kaplan et al. 1981).

Aven (2012:42) finds that the best possible definition for measuring risk is the combination of consequences and uncertainty (C & U). This differs from the definition of ISO 31000:2009, but only so little that Aven (2012) describes the ISO 31000:2009 as a special case from the C & U definition.

Uncertainty

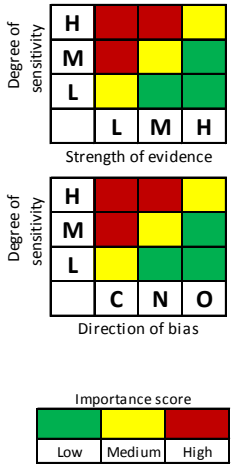
A risk assessment, as any predictive assessment, inherently contains uncertainties. The assessments are based on models describing the inherently uncertain world, be the model in the assessors mind or explicated as mathematical formulas. The question is not whether or not uncertainty is involved in an assessment, management strategy, or analysis, rather it is how much uncertainty is involved. The identification and characterization of the uncertainties and weaknesses related to the models, methods, and expertise used to assess and manage risk is imperative to the credibility of RM. (Modarres 2006:12).

In some cases, a division can be made between epistemic (reducible) and aleatory (not practical to reduce) uncertainties (Modarres 2006:335). This might facilitate a better decision making process in RM.

Bias

Bias is defined by the Bloomsbury Reference Dictionary (1994) as "that which causes the mind to incline towards a particular object or course; inclination; bent; prejudice". In the context of risk management, bias can be understood to cause the results of assessments to consistently differ from an "objective" or most likely value.

Bias can be unwilling and go unnoticed, or it can be a willing and very aware decision, such as when a civil engineer conservatively decides to double the thickness of a concrete beam to guarantee the strength of a structure, acknowledging that the actual strength of the structure is likely to be a lot bigger than the one stated to the customer.



Strength of evidence		
L	Low	All of the following conditions are met a) Data is not available, or is unreliable b) The assertion is seen as unreasonable c) There is lack of consensus among experts d) The phenomena involved are not well understood; models are non-existing or are known/believed to give poor predictions
M	Medium	Conditions between those characterizing low and high
H	High	All of the following conditions are met a) A lot of reliable data is available b) The assertion is seen as very reasonable c) There is broad agreement among experts d) The phenomena involved are well understood; existing models are known to give good predictions
Direction of bias		
C	Conservative	The evidence is believed to lead to conservative characterizations compared to the unknown accurate level, i.e. an overestimation
N	Neutral	The evidence is believed to lead to value-neutral characterization
O	Optimistic	The evidence is believed to lead to optimistic characterizations compared to the unknown accurate level, i.e. an underestimation
Degree of sensitivity		
L	Low	Model element has a significantly higher sensitivity than other elements
M	Medium	Model element has a sensitivity value in the middle range
H	High	Model element has a significantly lower sensitivity than other elements

Figure 5: An evidence assessment scheme for Bayesian Network risk analysis, adapted from Goerlandt & Montewka (2015:47).

There is a number of sources for bias in risk management, and as such their existence itself should not be problematic. The problem arises, when unacknowledged bias is linked to uncertainties about relatively large risks. The connection is depicted in Figure 5, which describes an evidence assessment scheme for selecting alternative hypotheses. This was used by Montewka et al. (2015) to identify the riskiest of their evaluations.

Categorization of risks

The FTA (2016) divides risks into operational, process, and strategic risks, depending on the level of organization on which the risk affects. Using this division, all the risks in the FTA waterway projects fall into the category of operational risks.

However, from the perspective of the ERM contingency theory, Mikes & Kaplan (2014) divide risk into three categories:

1. Preventable risk, which arises from routine operational breakdowns and undesired employee actions.
2. External risk, which the organization cannot influence itself, but only prepare for.
3. Strategy execution risk, which inherently follows from the business decisions to generate returns (or in the case of waterway projects, from the decision to provide transport network services).

This division is mostly in accordance to Nocco & Stulz (2006:8–10). These categories appear to provide a good basis to determine the most suitable actions to control a risk.

Conducting a risk assessment

During a risk assessment the possible risks or hazards are first identified, then their mode of action and possible consequences are analysed, and last their significance is evaluated; whether they should be concerned about and taken action, or not. The process of a risk assessment according to ISO 31000:2009 is depicted in

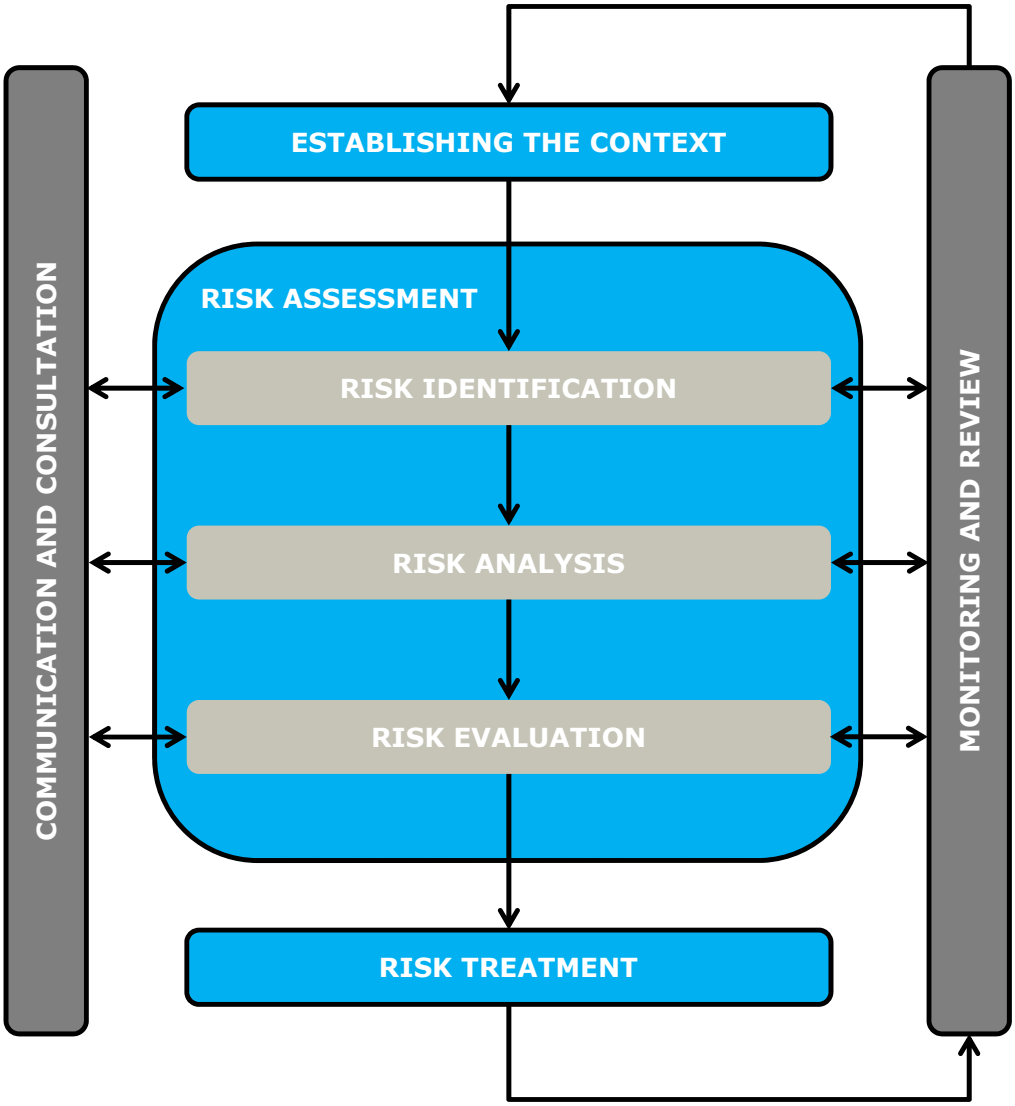


Figure 6: RM process as described in ISO 31000:2009.

A variety of methods and approaches exist for each of the phases of a risk assessment. An encompassing analysis of commonly accepted risk assessment methods can be found in the standard ISO 31010:2009, along with their delimitations and strengths.

The assessment methods presumably most often used in the FTA projects are indirectly defined in the Liikennevirasto (2015) guideline as "the essential tools for risk management". In the context of construction and maintenance projects, these include hazard checklists, a risk matrix, and a risk management plan form with columns for risk analysis, treatment, and follow-up.

The first part of a risk assessment, risk identification, produces the causes and source of the risks, and the events, situation or circumstances under which the threat or opportunity affects the objectives. The result is often a list of identified risks and a description of their nature.

The second part, risk analysis, should provide an understanding of the identified risks according to the adopted risk definition, which in the case of ISO 31000:2009 is the effect of uncertainty on objectives. Risk analysis involves consideration of the causes and sources of risk, their positive and negative consequences, the likelihood that those consequences can occur, and the availability and effectiveness of existing controls. These can be expressed in various ways, with various degrees of detail, and the process of risk analysis should reflect this. For example, the consequences and the likelihood can be expressed as point values, or they can be expressed as distributions, enabling the different sources of uncertainties to affect the result of the analysis and the way the result should be understood.

In order to provide a credible estimation of risk in a given frame, the correlation between the different risks and their sensitivity to external factors should be accounted for in the analysis (ISO 31000:2009). E.g. the change in the value of a navigation mark is likely to correlate with the value of dredging work, as they both are tied to inflation. Or the results of a risk analysis could be sensitive to the experienced level of analyzer confidence, especially in an environment which is difficult to forecast (Kahnemann 2011:209–221).

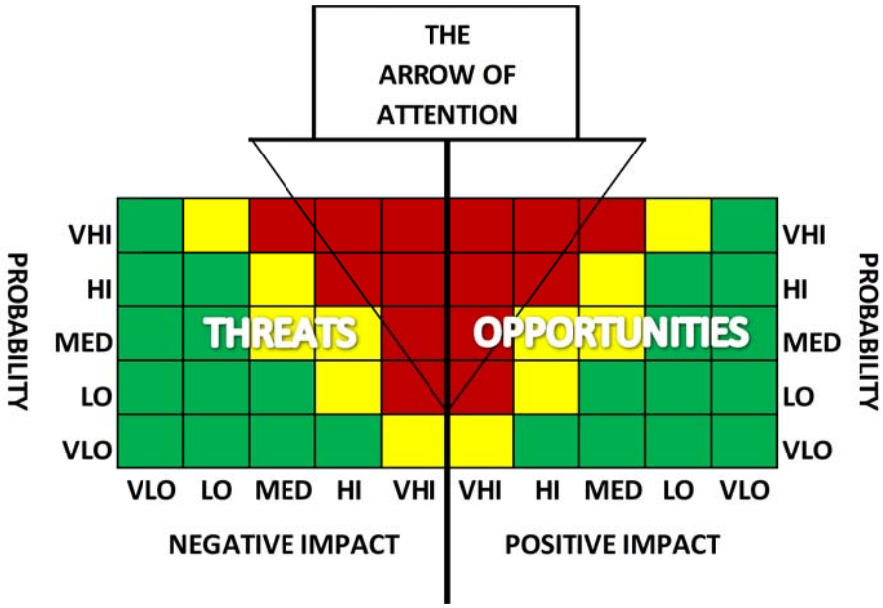


Figure 7: A qualitative risk matrix including both positive and negative dimensions of consequences. Adapted from Hillson (2002:238).

A common differentiation is done between qualitative and quantitative risk analysis. A qualitative risk analysis accounts for the risk on scales with verbal values, without a clear and exact connection with any numerical or probabilistic values. A quantitative risk analysis, on the other hand, produces all the values on a numerical and probabilistic scale, resulting in a significantly more precise definition of the risks. A semi-quantitative approach can be found in between, where the probability and consequence are divided into categories, which are described with numerical values. For example, a risk analysis conducted with a risk matrix can be either qualitative or semi-quantitative, depending on the matrix and the procedure of the analysis. *Figure 7* depicts a risk matrix supporting a qualitative risk analysis. (ISO 31010:2010).

According to ISO 31000:2009, the risk assessment process ends with risk evaluation, where the result of the risk analysis is compared with risk acceptability criteria, and the risks' acceptability or intolerability is evaluated.

Risk assessments play a significant role in risk management processes. The exact definition of a risk assessment varies depending on the applied standard, but for the use of this thesis the ISO 31000:2009 definition is used, as this is in accordance with Liikennevirasto (2015).

To sum up, "Risk assessment provides decision-makers and responsible parties with an improved understanding of risks that could affect achievement of objectives, and the adequacy and effectiveness of controls already in place. … The output of a risk assessment is an input to the decision-making processes of the organization." (ISO 31010:2010).

ISO 31000:2009 risk management process

The risk management process model described in ISO 31000:2009, and used in Liikennevirasto 2015, comprises of the following parts: establishing the context, risk identification, risk analysis, risk evaluation, risk treatment, monitoring and review, and communication and consulting. The process flowchart is depicted in

By establishing the context, the organization articulates its objectives, defines the external and internal parameters to be taken into account when managing risk, and sets the scope and risk criteria for the risk management process. Establishing the context is the process of answering e.g. the following questions: what are the constraints under which risk management is carried on; what is the environment and the regulations, internal and external to the organization at hand? What is the scope, strategies and parameters of the activities of the parts of the organisation where risk management is being applied?

After establishing the context, and assessing the risks, the treatment of the risks is planned. Risk treatment is generally regarded to have four possible options when discussing negative risk: avoid, transfer, mitigate and accept. The corresponding actions for positive risks are to exploit, share, enhance and ignore (Hillson 2002:238–239). The objective of the risk treatment is rarely to minimize the risk with negative consequences and to maximize the positive risk, as this would likely result in treatments with unreasonably high cost. Rather, the risk treatment decisions should usually aim for a level of risk which is a compromise between the cost of further risk treatment and the expected effect of the remaining risk. This level is often referred to as "As Low As Reasonably Practicable (ALARP)" (Modarres 2006).

The constantly ongoing RM processes include monitoring and review, and communication and evaluation. Monitoring and review ensures that the risk documents and plans are up-to-date and the treatments effective, while communication and consultation works to keep all relevant stakeholders and organization members acknowledged of the risks and their treatment.

ISO 31000:2009: "Risk management can be applied to an entire organization, at its many areas and levels, at any time, as well as to specific functions, projects, and activities." Risk management principles are not dependent on the scope of risks, and guidelines may be presented on a general level to fit "managing any form of risk in a systematic, transparent, and credible manner, and within any scope or context."

Another risk management process, especially designed for projects, is described in the PMBOK (PMI 2013), and discussed below.

2.5 Project risk management

PMBOK project risk management process

PMI (2013:311) defines risks related to a project as project risks, thus making a division between the regular risks to an organization and project risks. PMI (2013:312) divides the project risk management process into six phases on a linear continuum, as described in *Figure 8*.

At least the following relevant differences can be observed between the ISO 31000:2009 and PMBOK (PMI 2013):

1. The RM process is described as linear instead of cyclical. The temporary nature of projects has likely caused PMI (2013:312) to describe project risk management on a simple linear continuum instead of the cyclical, ever-repeating process described in ISO 31000:2009. This does not mean, however, that the process would not be cyclical, as the Control Risks process includes the item Risk Reassessment. Yet the way this is depicted in PMBOK is clearly different from ISO 31000:2009.
2. Risk analysis is specifically divided into a qualitative and quantitative part.
3. Monitoring and review, and communication and consultation are replaced by a single process: Control Risks.

The PMBOK (PMI 2013: 27–28; 313–318) describes the process of planning risk management in a project. It assumes that certain inputs are available from the organization when a project is started. From the viewpoint of risk, these include the following:

1. Risk categories
2. Common definitions of concepts and terms
3. Risk statement formats
4. Standard templates
5. Roles and responsibilities
6. Authority levels for decision making, and
7. Lessons learned.

PMBOK RM process	Multi-organizational RM process (MORM)	Owner (O)	Architect (A)	PM consultant (PM)	Main Contractor (MC)
Plan RM	Plan multi-organizational RM	Plans MORM for early phase	Plans own role in MORM	Plans MORM for construction works	Plans own role in MORM
	Select and commit participants	Plans proc. strat., tender process and contracts for A and PM	Follows tender requirements on RM	Follows tender req. on RM; Plans tender process and contracts	Follows tender requirements on RM
Identify risks Qualitative risk analysis Quantitative risk analysis	Identify and assess project-specific risks	Investment risk mapping; Workshop meetings	Owner's expert in risk mapping, workshops and meetings	Manages workshop and meetings	Site management risk mapping Workshop and meetings
Plan responses	Plan responses	Manages meetings and risk response plan for investment	Participates meeting procedures and risk responses	Manages meetings and risk response for construction works	Participates meting procedures and risk responses
Monitor and control risks	Monitor and control risks	Coordinates early phase updates for MORM	Updates own risks in MORM	Coordinates construction phase updates for MORM	Updates own risks in MORM
	Monitor and control collaborative performance	Participates MO feedback	Participates MO feedback	Facilitates MO feedback	Participates MO feedback
	Utilise collective learning	Participates lessons learned	Participates lessons learned	Facilitates lessons learned	Participates lessons learned

Figure 8: The multi-organizational RM process, MORM, adapted from Lehtiranta (2014), along with the traditional PMBOK process. Note that Lehtiranta describes the MORM process to include multiple feedback loops, the longest line is from collective learning back to committing and selecting participants.

The PMBOK Guide (PMI 2013) uses the term "Control Risks" for the process of implementing risk response plans, tracking identified risks, monitoring residual risks, identifying new risks, and evaluating risk process effectiveness throughout the project. The Control Risks process is used to determine if:

1. Project assumptions are still valid,
2. Analysis shows an assessed risk has changed or can be retired,
3. Risk management policies and procedures are being followed, and
4. Contingency reserves for cost or schedule should be modified in alignment with the current risk assessment

The PMI (2013:312) risk management process is further extended for use in multi-organizational context by Lehtiranta (2014), which is discussed in the following section.

A multi-organizational extension to project RM process

Lehtiranta (2014) describes a risk management process for projects with several organizations (see *Figure 8*). The foundations of the process lie firstly on the project risk management process described in the PMBOK (PMI 2013), and secondly on complexity theory and its applications to project risk management.

As the waterway projects run by the FTA always include more than one organization, the multi-organizational approach is noteworthy. Lehtiranta (2014) points out that the traditional project risk management theory is the most useful for simple project organizations, while the complexity-based project risk management theory has better applicability for complex project organizations.

The MORM systematic presentation of parallel RM processes in multi-organization construction projects guides construction project managers more efficiently, setting up the RM process for their multi-organizational projects. A multi-level process chart enables participants to understand their roles more easily than in case-by-case project RM plans. MORM is designed to respond to the complexity of construction project risks by systematically increasing the opportunity for risk communication, response innovation, and flexible sharing of risk responsibility. (Lehtiranta 2014).

However, the MORM process is not applicable to waterway projects as such, as it is designed to meet the needs of a PM consultant run building construction process. Yet the structure is not irrelevant, as the waterway project organizations may include similar sub-organizations as described in the MORM process. E.g. the one of the case projects includes two separate owners, a PM consultant, and the main contractor (MC). Still, the process needs to be specifically adapted to fit each project's needs and organization.

Furthermore, Lehtiranta (2014) strains that the use of MORM requires all focal participants to understand its principles, have appropriate access to the related tools and documents, and be committed to systematic risk management.

2.6 Waterway specific risk management approaches

A number of detailed risk management procedures and guidelines have been developed by international organizations for the context of waterways. These include the Formal Safety Assessment (FSA) by the International Maritime Organization (IMO 2002), a highly technical and complex risk assessment guideline, designed to provide a clear justification for proposed regulatory measures and to allow comparison of different options (IMO 2016). Another example is the Risk Management Guideline 1018 by the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA 2013), which is intended as a general description on RM methodology for marine Aids to Navigation (AtoN).

However, these guidelines are specifically applicable only to the planning phase of waterways or marine vessels, and therefore are of little to no use in the construction or maintenance phase of waterways, and do not bear additional value to the application compared to the ISO 31000:2009 and PMBOK (PMI 2013) guidelines.

In addition to the RM approaches that are international by nature, a brief comparison was made concerning the waterway project risk management approaches in Sweden and Denmark. The project setting in these countries differs from the setting in Finland, and their relevance to the FTA waterway project RM framework development varies depending on the context. The available guidelines from Denmark (Transportministeriet 2010 and Soefartsstyrelsen 2013, 2016a, 2016b) focus on the financial and navigational RM of waterway project risks, and provide a basis for benchmarking risk management approaches during the whole timeline of single infrastructure projects. However, they leave the practical RM related to project management in construction and maintenance phase projects somewhat undiscussed. The available guideline from Sweden (Sjöfartsverket 2016), on the other hand, discusses the risk management process from the perspective of organizational objectives. While being on a very practical level, it provides only limited relevance to construction and maintenance phase projects. The understanding of the Sjöfartsverket's approach to RM was complemented with several interviews, as discussed in Section 4.2. Summaries of the Danish and Swedish RM documents can be found in Summaries of waterway project RM guidelines in Sweden and Denmark.

3 Methodology

3.1 Research approach

The research falls into the domain of constructive research, which aims to solve practical problems while producing an academically acceptable theoretical contribution. Constructive research is pragmatic, and is interested on the instrumental value of knowledge in dealing with practical problems. The constructive research approach may be regarded as a form of case/field research, with the research result consisting of the construct itself, and of the practical and theoretical contribution of the work. (Kasanen et al. 1993:246, Lukka 2000, and Lehtiranta 2014:18–20).

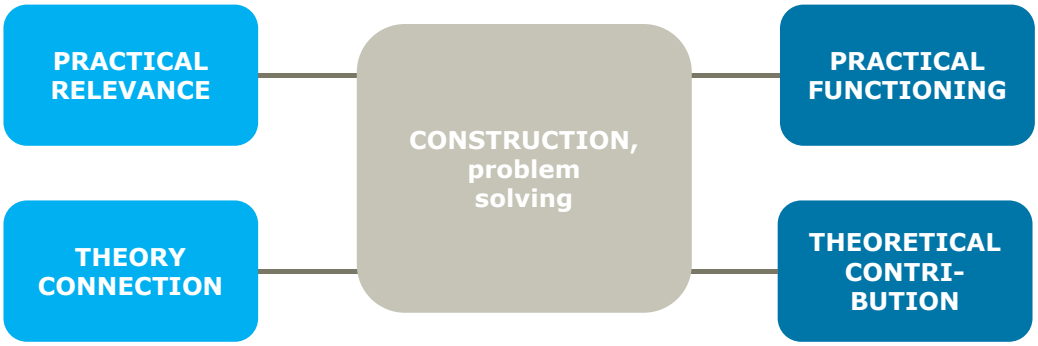


Figure 9: The elements of constructive research, adopted from Kasanen et al. (1993:246).

The constructs developed during this work are managerial constructs; they deal with managing risk. Thus, the managerial construction research framework described by Kasanen et al. (1993) and Lukka (2000), and later used by Lehtiranta (2014) in the context of risk management in construction projects, was determined applicable to this research (see *Figure 9)*. Kasanen et al. (1993:246) characterizes the approach by dividing it into the following six phases:

1. Find a practically relevant problem which also has research potential
2. Obtain a general and comprehensive understanding of the topic
3. Innovate, i.e., construct a solution idea
4. Demonstrate that the solution works
5. Show the theoretical connections and the research contribution of the solution concept
6. Examine the scope of applicability of the solution

The reasoning logic of constructive research ultimately follows that of abductive inference. Although stronger deductive and inductive inferences are included in this process, the strength of the reasoning of the process as whole is limited. (Shank 2008).

It should be noted, that the failure of a developed construct does not implicitly mean failed research; instead, a failure on the practical level can still have significant theoretical implications through the refinement and improved understanding of the theory (Lukka 2000).

3.2 Research process

3.2.1 Literature review

First, pre-understanding relevant to the research subject was obtained through a literature review. The answers to the following questions were sought for in the literature:

1. What is a waterway, in which quantities are there waterways in Finland, and how are waterway projects defined by the FTA?
2. What is risk and how does that relate to risk management and risk management frameworks?
3. How do practical project risk management approaches differ from organizational RM?
4. How are waterway risk management approaches described in international publications?

This information was gathered from the FTA guidelines, and from applicable standards. Further depth on the subject was pursued in relevant scientific literature. The results of the literature review are represented in Section 2.

3.2.2 Expert survey

An internet-based survey was set up for the participants of a national waterway seminar directed to FTA employees and representatives of private service providers; dredging and maintenance contractors, harbours and pilotage providers. The survey was sent to altogether 117 recipients, of which 48 answered.

The objectives of the survey were to give:

1. Insight on the experience and attitudes towards risk management in the waterway industry in Finland
2. Ideas on the development of the waterway project RM framework

After answering a number of questions about their background, the participants were first asked to evaluate their experience of RM in different types of waterway projects, then the experience they had on managing different risk types in these projects, for the third the benefits and drawbacks they identified in RM, and for the last they were asked for possible ideas or recommendations they had for developing the framework for waterway project RM.

Based on the respondents' personal evaluation, they were given a "RM experience score" on an ordinal scale from 1 to 5, and a "Risk type experience score" on an ordinal scale from 1 to 3. The benefits of RM were asked to be identified from a list based on ISO 31000:2009, with "project facilitation" as an additional list item. The drawbacks were asked to be identified in a similar manner, although the list was not based on any external source.

The survey form and the methodology of the experience scores are discussed in the Survey scoring methodology and survey form.

3.2.3 Semi-structured interviews

To complement the information from the literature review, altogether nine expert semi-structured interviews were held as a part of the research, seeking out an understanding of the current practice and the views held by the practitioners both in Finland and Sweden. The objectives of the interviews were to provide:

1. An understanding of the current practices of waterway project risk management in Finland
2. An understanding of the risks encountered in waterway projects
3. The possibility to compare risk management frameworks to the ones used in waterway project risk management in Sweden
4. Views of the current practitioners in terms of e.g. possibilities for enhancement of risk management and properties of a risk management framework they hold important

The interviewees were first contacted to prime the participants for the forthcoming interview phases and to schedule meetings or corresponding video calls. Next they were approached with an e-mail containing the interview questions for the interviewees to prepare, and then the experts were interviewed virtually or face-to-face.

The questions asked during the interviews are listed in the Interview Questions. The interview discussions were allowed to deviate from the questions, giving depth to the subject. The interviewer actively participated in the conversations and the interviews through additional questions and arguments.

3.2.4 Evaluation of the current FTA practice of waterway project RM

The obtained understanding was then used to evaluate the existing FTA waterway RM framework in accordance to the technical report ISO 31004:2013 for implementing the risk management standard ISO 31000:2009. The result is one interpretation of the implementation level of the ISO 31000:2009 from the FTA waterway projects' perspective. The evaluation provided a systematic, although imperfect analysis of the FTA's development possibilities, which were later utilized as the basis for the development of risk management constructs.

The ISO 31004:2013 technical report suggests the following steps for the design and implementation of a RM framework:

1. Compare current practice with that described in ISO 31000:2009.
2. Identify what needs to change and implement a plan for doing so.
3. Maintain ongoing monitoring and review to ensure currency and continuous improvement.

The first phase of the adopted design process is to evaluate the existing framework and practice against the ISO 31000:2009. This is divided into the evaluation of the principles of RM, the evaluation of the previous framework, and the evaluation of the RM process.

For the application in this thesis, the meaning of the second step was changed to correspond to "Identify and discuss what could be changed and define the constructs that could be developed to help achieve the change". The third step was omitted due to being outside the scope of this thesis.

Instead of seeing the evaluation results as an absolute statement, the value of the evaluation is the ability of the evaluation to provide development possibilities leading to successful constructs.

3.2.5 Development of waterway project RM constructs

In the context of creating managerial constructs, in most cases, the simplest idea is the most adequate one. Thus, a working construct is relevant, simple, and easy to use. (Kasanen 1993:259).

The chosen RM framework development possibilities were addressed by five separate risk management constructs. The choice was made based on their appropriateness for being developed in the framework of a thesis, on the necessity of the development, and on the ability of the available validation possibilities to address the functionality of the development. This resulted in the following constructs:

1. A RM process tied into the lifetime of waterway projects, meant for integration into the other organizational processes of the FTA
2. Waterway specific hazard checklists
3. Opportunity management as a part of RM
4. A modified version of the FTA risk analysis process using a risk matrix
5. A model for establishing the context of the risk management process

The constructs were first developed as a "best guess" approach about the identified development possibilities' potential for construct development.

After the creation of the first versions of the constructs, a workshop was held, attended by a number of FTA experts on waterways and risk management. The participants commented the constructs and provided further development ideas. This feedback was utilized in the development process, and the final versions of the constructs were developed based on the feedback from the validation process described below. The constructs are described in Section 4.4, and they can be found in full scale in the The constructs.

3.2.6 Construct evaluation and validation

The construct validation process consisted from a development workshop, three case studies, and a number of external commentaries on the constructs. Pilot case studies are the preferred means to test and improve a construct (Oyegoke 2011), and thus their weight in the development process is regarded as more significant than of the workshop and the commentaries.

The development workshop was attended by FTA RM and waterway experts (as described above) and the whole combination of constructs were discussed, although on varying levels of depth.

The three case studies are shortly described below, along with the corresponding participants. All the case studies were additionally participated and facilitated by the author and a RM expert.

1. Case A, a construction-phase harbour development project combined with the deepening of an existing waterway on the Baltic Sea. The case study took place about a month after the launch of construction works, and it was attended by the constructor, project management consultant, pilotage service provider, and both the client organizations; the harbour and the FTA, with the FTA also being represented by the RM sub-organization.
2. Case B, a care project on the Baltic Sea. The case study took place between the tendering process and the beginning of the contract period, attended by the service provider, and the client, RM, and commotional safety sub-organizations of the FTA.
3. Case C, an inland highway bridge replacement project, along with a change in the waterway alignment and corresponding dredging operations. The case study took place shortly before the tendering process of the construction works, attended by the client, RM, and commotional safety sub-organizations of the FTA.

The Cases A and C had risk management plans available for being utilized in this study. The plans included risks identified from both project management and safety and health perspectives.

Table 2: The validation process of the developed constructs. Read from left to right.

Validation process	I. FTA expert workshop	II. Case A	III. Condition mgmt group*	IV. Case B	V. Case C
1. Waterway project RM process	x		x		
2. Waterway hazard checklists					
- project management	x	x			x
- construction	x	x			x
- maintenance	x			x	
3. Opportunity management	x	x		x	x
4. Enhanced FTA RA process					
- consequence interval	x	x			x
- dual probabilities in matrix	x	x			x
5. Model for establishing RM context		x		x	x

* The construct validation part III. stands for the "FTA waterway condition management process development group"

The duration of each of the case studies was approximately three hours, including an introduction, risk identification, and discussion, of which contents varied. The studies were succeeded by a crude risk analysis and structuring of a treatment plan by the author, which was later commented by the case study participants. The themes covered during each case study are described in Table 2.

Construct validation parameters

The validation of the constructs was based on two factors:

1. The evaluation of the constructs in the frame of weak market testing.
2. The enhancements in the projects' RM plans, produced by the use of the constructs.

Kasanen et al. (1993:253) describe the market-based validation process of managerial constructs. He argues that the testing of the pragmatic adequacy of a construct takes time and requires several attempts of application. The following market tests are based on the concept of innovation diffusion, i.e., managerial constructs are viewed as products competing in the market of solution ideas.

1. Weak market test: Has any manager responsible for the financial results of his or her business unit been willing to apply the construct in question in his or her actual decision making?
2. Semi-strong market test: Has the construct become widely adopted by companies?

3. Strong market test: Have the business units applying the construct systematically produced better financial results than those which are not using it?

An essential precondition to the application of market-based validation of managerial constructs is the existence of the market of managerial solution ideas (Kasanen et al. 1993). The role of the FTA in the Finnish waterway projects ensures that the potential market of the constructs is mostly limited to government-run projects, inflicting that the true competition on the market of managerial solution ideas is perhaps more questionable than in companies operating in the market. Thus, the necessary but simplifying assumption was made, that the FTA project management have at least a collective ability to adapt to managerial circumstances and new ideas, which would entail the concepts of innovation diffusion and market testing to be valid in evaluating RM constructs for Finnish waterway projects.

A weak market test was determined as approved, if two or more in an FTA waterway project organization found the construct useful or successful in their work, and the possible critique expressed by them or others during the validation process was insignificant in comparison (e.g., the critique concerned a minor detail that could be changed without compromising the functionality of the construct).

The enhancements in the RM documentation consisted of risks that had previously not been recognized in the RM plans. In the Case C, these enhancements also included improved treatment options for previously identified risks.

4 Results

4.1 The environment for RM in the Finnish waterway industry – survey results

4.1.1 Survey respondents

The Internet-based survey was used for building up insight on the experience and attitudes towards risk management in the waterway industry in Finland. The 48 respondents corresponded to the service providers and infrastructure managers involved in waterway projects in Finland. Of these 19 represented the FTA and 29 represented private companies: dredging and maintenance contractors, harbours and pilotage providers. The respondents' offices had a decent areal spread along the Finnish coast and the most important freshwater waterways.

Of the 48 respondents, 36 had been involved in a waterway-related risk assessment, or claimed further professional responsibility on waterway RM.

35 of the respondents were, or had experience of being managers, management consultants, or entrepreneurs. Only two of these had less experience in RM than participation in a waterway-related risk assessment. Of the remaining, 12 had experience in maintenance, planning, surveying, or permits. One respondent did not clearly state the contents of his work.

4.1.2 RM experience

The data shows that the respondents have a wide experience of RM in different types of waterway projects. Freshwater waterway RM experience is represented less in the data than sea waterway RM experience, with the average RM experience scores corresponding to 1,75 and 2,38 on the scale from 1 to 5.

While other explanations can be equally valid, the scores appear to be in relation to the total length of high priority waterways in freshwater and sea environments, contributed by the additional workload due to the locks and bridges on the freshwater waterway network. Given this assumption, the respondents appear to represent the Finnish waterway projects fairly well.

The average Risk type experience score for each risk type were relatively close to each other for safety, economic, environmental, quality and schedule risk (on a range from 2,10 to 1,88). Reputation and RM process risks had lower average scores (1,48 and 1,52), while political risk was almost not managed at all (avg. score 1,19). The low score of the political risk type could relate to a low level of political risk for waterway projects in Finland, or to a low level of credible risk control mechanisms for political risk.

4.1.3 RM benefits and drawbacks

Experience of RM in different types of waterway projects appears to have a small correlation to the perceived benefits and drawbacks of RM. However, even if the correlation were statistically significant, the level of the correlation is so small, that it doesn't make a difference in practice. This could be interpreted so, that experience in RM doesn't significantly affect the perceptions on the usefulness of RM. See *Figure 10*.

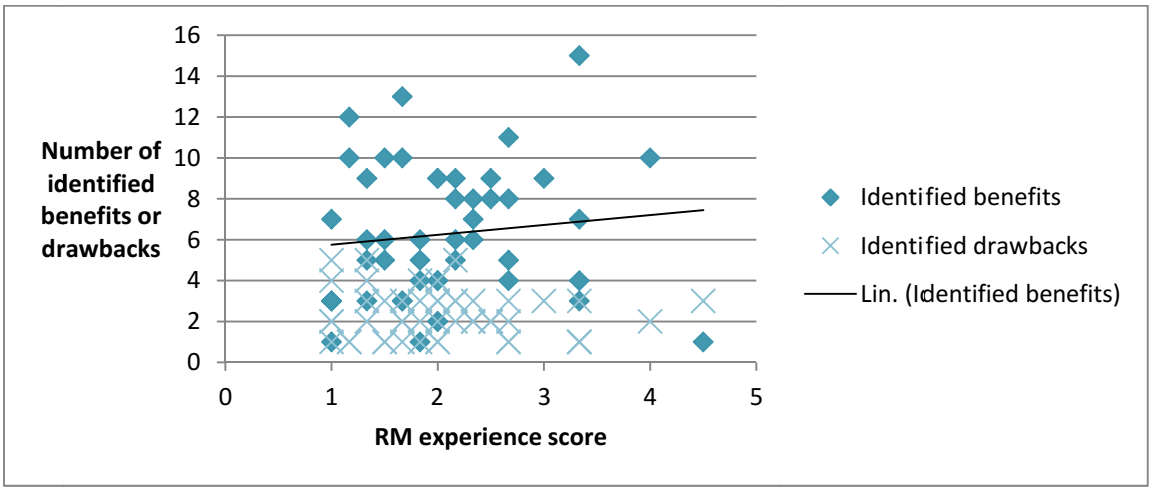


Figure 10: Survey respondent number of identified benefits and drawbacks plotted against their RM experience score.

Nevertheless, the identified benefits and drawbacks tell a story about the purposes RM is perceived useful for. *Table 3* and *Table 4* describe the count of the benefits and drawbacks identified by the respondents in different types of waterway projects.

Table 3: The benefits of waterway project RM identified by the survey respondents.

Identified benefits in waterway project RM	Times identified
Improvement in the identification of opportunities and threats	39
Enhancement in health and safety performance, as well as in environmental protection	38
Improvement of loss prevention and incident management	37
Encouragement of proactive management	25
Establishing a reliable basis for desicion making and planning	24
Improvement in information flow	20
Improvement in stakeholder trust	19
Improvement of organizational learning and resilience	19
Improvement in reporting	15
Effective allocation and use of resources	15
Increasing the likelihood of achieving objectives	13
Enhancement in expense control	12
Facilitating of carrying out projects	10
Improvement in operational effectiveness and efficiency	10

Table 4: The drawbacks of waterway project RM identified by the survey respondents.

Identified drawbacks in waterway project RM	Times identified
Increase in workload	32
Increase of expenses	22
Increase of useless bureaucracy	20
Increase of requirements	18
Focusing on irrelevant	13
Weakening of information flow	1
Deterioration of stakeholder trust	1

The gap between the most and least often identified benefits of RM is relatively large. The first four items in *Table 3* were identified by more than a half of the respondents. These items include the ones pursuing proactiveness in risk management and identification, as well as health, safety, and environmental protection.

The last four items in *Table 3* were identified by less than or about quarter of the respondents. These include items pursuing efficiency, expense control, and facilitation of projects and achieving objectives – economic values.

The list of identified drawbacks in *Table 4* speaks the same language: the items "Increase in workload" and "Increase in expenses" were identified the most. However, RM is not seen completely irrelevant, as only a quarter of the participants recognized "Focusing on irrelevant".

4.1.4 Discussion and conclusions about the survey results

The survey results indicate that the attitudes towards waterway project RM are not affected by the amount of experience in RM.

Safety, economic, environmental, quality and schedule risk are managed the most in the Finnish waterway projects. However, the respondents appear to believe RM is not nearly as good a tool for pursuing economic, quality and schedule efficiency, than it is for pursuing safety and health, and environmental protection.

The majority of the respondents currently had a managerial job description. They were also almost identically the ones with waterway RM experience. While it is likely that the managers are the ones managing risk in practice, it is also possible that the practical level risk management is being done by others, not included in the survey, and thus the results of the survey would only describe a part of the practice of waterway project RM. However, the managers are likely the ones also making decisions about RM and its applications, diminishing the possible effect of subordinates.

Another possible source for bias is that the respondents likely didn't significantly strain their thinking during the survey. The questions were relatively challenging, if given due attention, and as such the answers more likely reflect the respondents' quick conceptions than their best understanding. (See, for example, Kahnemann 2011:19–105).

The results did not appear to differ significantly between the FTA employees and other respondents.

4.2 Waterway project RM in the FTA and Sjöfartsverket – expert interviews

4.2.1 The interviewees

Altogether twelve (12) waterway construction and maintenance experts were interviewed. The interviewees were either managers (10) or project managers (2) of some kind, and they had their backgrounds in sea- (6) and freshwater (6) waterways, both in construction (3) and maintenance (9). The interviewees represented the public (5) and the private (3) sector in Finland, and the public sector in Sweden (Sjöfartsverket, 4 interviewees).

All the interviewees believed their own knowledge in risk management to be adequate, given their professional roles. Yet most of the interviewees involved in maintenance admitted that they could as well have more knowledge.

4.2.2 The state of waterway project RM in Finland

The eight Finnish interviewees described that RM is an appreciated and well established part of waterway projects. The details, however, clearly differed between the waterway construction and maintenance projects.

Health and safety risks, and supposedly environmental risks, were recognized well managed in all projects. This is at least partly due to laws and regulations, calling for encompassing safety documentation and assessment from both the client's and the service provider's side. By strictly adhering to the regulations about the required paperwork, the client's project management secures their own back in case of an accident, and transfers a part of these responsibilities to the service provider. The downside of these regulations is a big amount of safety documentation and associated workload per project, while the actual impact on occupational safety by the documentation itself is small; e.g. the buoy light repairer himself is not likely to both read and internalise the tens of pages of text, given that the text somewhat repeats itself from project to project.

A more clear division between the lifecycle phases of waterways derives from the economic RM perspective. While most of the monetary value of the waterway is tied in and decided for in the planning phase, some economic risks persevere to the construction and maintenance phase, while new risks arise. The interviewees with experience in waterway construction projects conceived the economic perspective of RM to be in a good state in those projects, while the ones with maintenance background identified the economic risks to have been left outside the focus of the RM practices. *Table 5* depicts the risk management perceptions of the eight Finnish interviewees. Subjective in its nature, it provides a qualitative image of managerial-role interviewees, and describes these differences between the construction and maintenance projects

Table 5: RM perceptions of the eight Finnish interviewees.

Interview summary	Planning and projects (3)	Maintenance (5)
Has positive experience of the "essential tools of RM"*	x	x
Identifies benefits in RM	x	x
RM includes more than just health and safety risks**	x	½
Health and safety RM		
RM is a regular routine	x	x
Benefits from RM have been monitored	x	x
RM is systematically a part of decision making	x	x
Project RM (without health and safety risks)		
RM is a regular routine	x	0
Benefits from RM have been monitored	x	0
RM is systematically a part of decision making	x	½

* Incl. hazard checklists, RM plans and risk matrices
**Health, safety and environmental risks are monitored regularly in site meetings in both maintenance and construction projects.

The FTA guideline defines "the essential tools of RM", with which risks are being analysed in waterway maintenance projects (Liikennevirasto 2015). These include a combination of hazard checklists, a risk matrix, and risk management plans. However, the hazard checklists only exist for occupational health and safety risks, while checklists for the project management concerns of waterway projects are not available. These could include e.g. procurement risks, or the uncertainty on the precise quantities of material to be dredged during the project.

The difference between the health and safety, and general routines for RM might be linked to the monitoring of the benefits of RM. The waterway industry, and the construction industry as a whole, has seen a significant decline in safety-related accidents during the last few decades, in which the systematic identification and minimizing of safety risks has no doubt played a remarkable role, along with the development of technology. The effect of a systematic approach to RM from an economic perspective RM was found more difficult to monitor and observe, which is likely to affect the attitudes towards economic RM.

Some of the interviewees pointed out, that the contractor and the client/project have different responsibilities and thus perceive risks differently. They shared the opinion that the waterway planning phase risks are not managed properly. The latter could have an influence to both construction and maintenance phase RM.

It is also noteworthy, that the system for providing risk information flow between the FTA projects was found unclear, and that while the principles of the flow were described in the FTA guideline, the practical application of the principles did not exist.

4.2.3 Waterway maintenance and projects in Sweden

The waterway infrastructure in Sweden is maintained by Sjöfartsverket, a similar public organization as the FTA, but focused only on waterways instead of roads and railways as well. These, along with large waterway projects are entrusted to Trafikverket, where large projects are defined as being approximately worth more than three billion Swedish kronor (or about 300 M€). The maintenance of waterways is defined similarly as in Finland. The maintenance works are mostly conducted by employees of the Sjöfartsverket, and thus private companies play a significantly smaller role in maintenance than in Finland.

On the contrary, minor waterway construction projects are conducted in a fairly similar manner as by the FTA: Sjöfartsverket is the client, and private service providers conduct the work. However, project management consultants play a less significant role, as the project organizations on the client's side comprise of about 50-50 of Sjöfartsverket's employees and private consultants.

Maintenance

While the maintenance organization of the Sjöfartsverket is different to the FTA maintenance projects, the approach for RM is quite similar. Risks are analyzed using a risk matrix, and then listed on a RM plan. RM always takes into account the economic, social, and environmental risks – which correspond to the three pillars of sustainability. However, the maintenance department interviewees appeared to put most weight on the safety risks, or the risks encountered in their daily work, which can be seen as a logical consequence from having their own employees at risk.

The maintenance department interviewees also recognized the possibility of the management of positive risks, while having to admit that they are rarely to be identified on the project level, but more often on the organizational, or process level.

Sjöfartsverket construction projects

The interviewed Sjöfartsverket project manager for construction projects discussed the project management side of RM. He claimed that the use of partnering contracts has significantly improved the quality of project RM compared to the use of fixed-budget contracting. This is achieved through the involvement of the constructor, designer and other possible stakeholders in the RM process, and their incentivizing with common stakes in project's success.

The described RM process itself was similar to the practice of the waterway projects in Finland, with minor differences in e.g. the way the risks are presented to the offerors in the tender phase, and in the elaboration of RM workshop frequency in the construction phase (quarter-yearly).

As a result of the successful experiences with partnering contracts, the private sector in Sweden was described to have culturally "grown up" in the use of RM, extending the benefits of the partnering contracts all the way to fixed-budget contracting, as the stakeholders have understood the power of mutual trust and successful RM. The mutual trust can be further supported by the client through the use of multi-day kick-off meetings after the tender phase, where all the stakeholders point out their goals and often realize that 80–90 % of their goals concerning the project are the same,

ending up with a kind of "partnering agreement" and a constructive social environment for the project.

However, some fixed-budget projects arrive with tensions between the stakeholders arising from the fear of one of the parties abusing the others for business intentions, in which case RM through common workshops was not seen as a beneficial tool for the successful accomplishment of projects.

The RM benefits were found hard to measure or monitor, but subjectively the benefits appeared obvious: the result isn't just a reduction in project risk levels, but better overall solutions for the project, reductions in costs and schedule, and improvements in efficiency. The key to success was claimed to be found in good and honest discussions between skilled people striving for a common goal.

4.2.4 Result validity

The sample of the interviewees was similarly biased as the respondents in the survey: both samples consisted of mostly or exclusively manager-level employees. Thus, the results emerging through both methods could be attributed as a fairly likely image of the reality perceived by the managers. It is, however, possible that the waterway-related managers have in average a biased view on RM conducted under their control, as they have personal stakes in the success of this RM.

Inductively, the results provided here do not entail the RM practices of the FTA projects, even when the results properly reflect the managers' understanding. Still, no better source was available for the information.

Additional biasedness to the results may have been inflicted by the interviewers' active participation in the conversations, and the subjective nature of the interpretation of the results. However, the results were not affected by the survey discussed in Section 4.1, as these interviews were conducted before the design of the survey.

4.3 Evaluation of the current FTA practice of waterway project RM against the ISO 31000:2009

The evaluation represents a fairly subjective and shallow understanding of the FTA waterway RM practice. Instead of seeing the results as an absolute statement, the value of the evaluation is the evaluation framework itself, and its ability to provide development possibilities leading to successful constructs.

4.3.1 Evaluation against the principles of RM

The standard ISO 31000:2009 defines eleven principles to be complied with in order for risk management to be effective. This is used as the starting point for the evaluation of the effectiveness and efficacy of the current FTA approach to waterway project RM.

ISO 31004:2013 claims the following "Rather than simply implementing the principles, it is important that the organization reflects them in all aspects of management. They serve as indicators of risk management performance and reinforce the value to the organization of managing risk effectively."

Table 6 describes the results of the evaluation of the RM principles. The left column lists the risk management principles, and the right side describes the subjective evaluation of the realization of the principles. In the middle a three-category classification gives an approximation of the level of ISO 31000:2009 implementation, where "x" stands for "good level of implementation", "½" for "partial implementation", and "0" for "not implemented".

As the evaluation is a subjective interpretation of the reality with incomplete knowledge of the subject, the conclusions made in the evaluation try to reflect this uncertainty.

Table 6: Evaluation of the realization of ISO 31000:2009 RM principles in the practice of waterway projects.

Risk management principle	Practice	Explanation
creates and protects value	½	Not demonstrable in the project quality or management application, nor does it appear to be much used for those purposes. Safety, on the other hand, is regularly followed through e.g. the anomaly and risk register TURI, and the effectivity of the recent approach can be observed e.g. through the change in safety culture during the last decade
is an integral part of all organizational processes	½	Safety and health RM is integrated into all tendering processes as far as possible. However, the project management risks, and the process risks covering all the kinds of projects have not even been identified, though this is under development at the FTA.
is part of decision making	x	While this is not completely clear based on the available knowledge, the interviewees claimed all the risk knowledge to be accounted for in the decision making.
explicitly addresses uncertainty	½	The risk assessments conducted with the help of a risk matrix express uncertainty through the use of semi-quantitative probability classes. However, the nature and cause of that uncertainty is left undiscussed, leaving the understanding of it on a superficial level.
is systematic, structured and timely	0	A systematic, timely and structured approach in e.g. a project's timeline does not exist, although the assessment of safety risks is inluded in all tender processes.
is based on the best available information	0	The inputs to the risk management process are mostly based on experience and expert judgement. However, the historical data and the risk assessments from previous projects is not accounted for. Furthermore, the possible divergence among experts is not taken into account in decision making, as the divergence doesn't surface to the risk management plans.
is tailored	½	The risk management approach is desinged explicitly for infrastructure construction and maintenance purposes. The available hazard checklists however do have a gap when it comes to waterway projects and their management.
takes human and cultural factors into account	?	The data does not provide clues of this information.
is transparent and inclusive	?	The data does not provide clues of this information.
is dynamic, iterative and responsive to change	?	The data does not provide clues of this information.
facilitates continual improvement of the organization	x	The notions that this work is being conducted and that TURI is being implemented for project RM purposes, provide anecdotal evidence of the continual development of the organization in terms of RM.

4.3.2 Evaluation of the risk management framework

In order for the FTA waterway project RM framework to be analyzed according to ISO 31004:2013, the documents, systems and information based on the interviews were arranged to fit the ISO 31000:2009 definition of a risk management framework. This is depicted in the *Table 7*, which describes the information sources and the available waterway project RM tools and systems, divided according to the ISO 31000:2009 RM framework definition. The documents 1–5 are publicly available to service providers, while the systems and guidelines 6–8 are available to FTA employees, and to service providers through agreements. Summaries of the documents and short descriptions of the systems can be found in the Summaries of the FTA RM framework documents and systems, and they are written from the perspective of waterway project RM.

The ISO 31004:2013 stresses that especially the subclauses 4.3.2 to 4.3.7 of the ISO 31000:2009 should be evaluated against the framework. These describe the design of a RM framework regarding policy, accountability, integration into organizational processes, resources, and establishing internal and external communication and reporting mechanisms.

Table 7: The building blocks of the FTA waterway project RM framework.

The building blocks of the FTA waterway project RM framework (ISO 31000:2009)	**1. FTA RM Principles**	**2. FTA Infra RM Protocol**	**3. Safety RM procedure**	**4. RM in railway planning**	**5. Risks in road care**	**6. FTA process mgmt**	**7. Safety and RM register**	**8. Tender and PM guidelines**	**9. Semi-structured interviews**	**10. Internet query**
Foundations										
policy	x	x								
objectives	x	x								
mandate									x	
commitment									x	x
Organizational arrangements										
plans						x	x			
relationships						x			x	
accountabilities							x		x	
resources		x	x	x	x	x	x	x	x	x
processes						x				
activities						x			x	

1. FTA RM Principles (Liikennevirasto 2016d)
2. FTA RM Protocol for transport infrastructure projects (Liikennevirasto 2015)
3. Safety risk management procedure for infrastructure projects (Liikennevirasto 2012)
4. RM in railway planning (Liikennevirasto 2010)
5. Risks in road care service agreements (Tiehallinto 2009)
6. The FTA process management system
7. Safety and RM register (TURI)
8. Internal tender and project management guidelines and contract forms

RM policy

The FTA risk management policy is described on a general level in Liikennevirasto (2016d), and infrastructure project specifically in Liikennevirasto (2015). These appear to be in line and support each other, together describing a clear and conformable policy, which reflects the principles of RM as described in ISO 31000:2009.

Accountability

The accountability and authority for managing risks in waterway projects is expected to usually be clear, as each of the projects is appointed a project manager. Their competence in RM is outside the reach of this evaluation, although the survey discussed in Section 4.1 does indicate they have due experience in RM.

It might prove worthwhile to establish a process for project management RM competence development, if such does not exist in the FTA.

Integration into organizational processes

The integration of RM into organizational processes is deductible through observation of the FTA process management system and the tender and project management guidelines. While it should be acknowledged that the process management system was under development during the writing of this thesis, it also noteworthy that it did not include RM as internal to the described processes from the project management perspective.

Instead, RM was described solely as a safety and health task, which is included as a part of the tendering process and work site meetings. Likewise, RM is included only as a safety and health related part of the tender process in the tender and project management guidelines.

Resources

Table 8: Evaluation of the adequacy of RM resources in the practice of waterway projects, as described in ISO 31000:2009.

RM resource category	Availability	Explanation
People, skills, experience and competence	½	The people and their experience levels are shortly assessed in Section 4.1 - however, the assessment of their skills and competence is not possible based on the available information. Note: see category below.
Resources needed for each step of the risk management process	½	A clear understanding of the sufficiency of resources for RM was not provided by the sources. However, one open comment by a FTA survey respondent noted the following: "Although the availability of benefits (through RM) is obvious, RM is often left disregarded due to the scarcity of resources." (Based on the survey described in Section 4.1). While the value of the comment is anecdotal, it does provide a due reason for the investigation of the subject.
The organization's processes, methods and tools to be used for managing risk	0	The RM process, methods and tools are publicly available for use. From waterway project RM perspective, the available hazard checklists do not include waterway-specific hazards. Instead risk identification is instructed to be conducted through the adaptation of other, somewhat applicable checklists. While this may in some circumstances be a valid approach, it requires expert knowledge, and would be more straightforward with especially designed hazard checklists.
Documented processes and procedures	½	The documentation of the RM process is on a superficial level when compared to the ISO 31000:2009 standard. The documentation focuses on risk identification and communication, leaving establishing the context, risk analysis, risk evaluation, and monitoring in practice undiscussed.
Information and knowledge management systems	½	The safety and RM register (TURI) was under implementation during the writing of this thesis. Waterway project risks were bound to be included in the system in the future. See Appendix 5: Summaries of the FTA RM framework documents and systems.
Training programmes	?	Information of RM training programmes for the FTA project management was not availble for this research.

The ISO 31000:2009 stresses the importance of appropriate RM resources in six categories. Their evaluation against the FTA waterway PM framework is discussed in *Table 8*, where the left column lists the risk management resources as defined by the ISO 31000:2009, and on the right a subjective evaluation of the resources in practice.

In the middle a three-category classification gives an approximation of the level of the resources, where "½" stands for "not enough resources for optimal RM", and "0" for "no relevant resources".

Internal and external communication and reporting mechanisms
While the FTA guidelines (Liikennevirasto 2015 & 2016d) describe how information should flow from a project to another, no clear mechanism is available for that purpose. The implementation of the FTA safety and RM register is likely to bring a possibility to exchange information efficiently.

However, the register's reporting mechanism is not capable of producing an overview of the risks concerning the projects of a given type, nor classifying or combining those risks to categories, and thus provides only limited possibility of benchmarking relevant projects' RM inside the FTA. This challenge does also relate to the method of risk analysis, see the Section 4.3.3 below.

The ISO 31000:2009 lists a number of other, additional purposes for the risk communication and reporting mechanisms. These purposes, however, are mostly relevant for other levels of the FTA RM hierarchy than project RM, or the information relevant for their assessment was not available, and therefore these purposes were not analyzed.

4.3.3 RM process

The FTA project RM process in construction and maintenance phases is based on the following essential tools of RM: hazard checklists, risk matrix, and risk management plan (Liikennevirasto 2015). The process and the tools are discussed phase-to-phase in the following sections.

Communication and consultation
The process of communication and consultation is not described in the FTA documents. The standard ISO 31000:2009 recommends a consultative team approach for the whole RM process, but how this relates to the FTA practice is not acknowledged by the author.

Liikennevirasto (2015) dictates that the use of expert workshops should be used as a source of risk information. However, the experts' roles are not extended beyond the risk assessments.

Establishing the context
Establishing the context is included in the guideline Liikennevirasto (2015) as a part of the RM process. However, it is not explained in any manner in the guideline. According to ISO 31000:2009, this should include establishing the external context, internal context and the context of the RM process.

It can be assumed, that infrastructure projects run by the FTA are conducted in a fairly similar context in comparison with each other, and thus the establishing of the external and internal contexts can understandably be omitted in some cases. Yet the third part, the context of the RM process is always different, as all the projects are different in a way or another. It might be worthwhile to give this part of the process due attention.

Risk identification
Risks in FTA waterway projects are identified with the help of varying hazard checklists. These are divided in Liikennevirasto (2015) into groups, which should be considered according to project phase and type.

From waterway project RM perspective, the available hazard checklists do not include waterway-specific checklists except for care service agreement projects – instead, risk identification is instructed to be conducted through adaption of other checklists. While this may in some circumstances be a valid method, it requires more expert knowledge and time than with especially designed hazard checklists.

ISO 31010:2010 lists the following strengths (+) and limitations (–) in the use of checklists as a tool for the risk identification process:

+ they may be used by non-experts
+ when well designed, they combine wide ranging expertise into an easy to use system
+ they can help ensure common problems are not forgotten

– they tend to inhibit imagination in the identification of risks
– they address the 'known known's', not the 'known unknown's' or the 'unknown unknown's'
– they encourage 'tick the box' type behaviour
– they tend to be observation base, so miss problems that are not readily seen

To counter the limitations of the check-list approach, ISO 31010:2010 recommends pairing of the checklists with a more imaginative technique that identifies new problems, with the imaginative technique preferably applied first. This imaginative technique could, e.g., be brainstorming of a kind, when applied in an expert workshop.

Risk analysis
Risks are analyzed in the FTA waterway projects with the help of a risk matrix on a semi-quantitative scale.

ISO 31010:2010 lists the following strengths (+) and limitations (–) in the use of risk matrices (or consequence/probability matrices) as a tool for risk analysis:

+ relatively easy to use
+ provides a rapid ranking of risks into different significance levels

– a matrix should be designed to be appropriate for the circumstances so it may be difficult to have a common system applying across a range of circumstances relevant to an organization
– it is difficult to define the scales unambiguously
– use is very subjective and there tends to be significant variation between raters
– risks cannot be aggregated (i.e. one cannot define that a particular number of low risks or a low risk identified a particular number of times is equivalent to a medium risk)
– it is difficult to combine or compare the level of risk for different categories of consequences

Results will depend on the level of detail of the analysis, i.e. the more detailed the analysis, the higher the number of scenarios, each with a lower probability. This will underestimate the actual level of risk. The way in which scenarios are grouped together in describing risk should be consistent and defined at the start of the study. (ISO 31010:2010).

However, the FTA guidelines do not provide much advice on how to use the matrix and thus acknowledge its limitations and shortcomings, fully exposing the risk management process to those limitations. Additionally, these drawbacks somewhat undermine the RM policy requirement for always comparing the risk and its treatment on a uniform scale, for how could this be possible, if the matrix's use and interpretation is very subjective? (Liikennevirasto 2016d)

The risk matrix is used in the FSA process as well, but its use is delimited to an initial screening of the risks, which is a part of risk identification, not analysis (IMO 2016:10).

For the last, it should be noted, that risk is defined here to include uncertainty relating to events with positive consequences. Equally, risk analysis (and assessment) should be focused to both negative and positive consequences, if consistency with the definitions is to be maintained. This should be reflected in the tools for risk analysis, if the positive consequences are to be identified and sought after through the process of RM.

Risk evaluation

Risk evaluation is conducted simultaneously with the risk analysis, as the risk rating achieved from the risk matrix corresponds to a policy on risk treatment. Thus, risk evaluation does not exist as a separate phase of risk assessment.

Risk treatment

The current risk management forms do not require analyzing the efficacy or efficiency of the chosen risk treatment. Instead, the treatment of single risks, is, at least sometimes, decided upon simultaneously with the analysis of the risk, without the truly questioning the treatment's capability of reducing risk (based on a statement by one of the interviewees).

With the implementation of the risk and safety register in FTA projects, analyzing the effect of the treatment becomes compulsory. This has the possibility to improve the level of risk management, but only if the analysis of the treatment is given due attention.

Yet even the analysis of the effect of risk treatment does not remove the problems of risk matrices; their tendency to produce subjective results. Without dealing with the problem of subjectivity of the risk analysis both pre- and post-treatment, it is impossible for the risk manager to stand behind the claim of the treatment's capability of reducing the risk a given amount.

Monitoring and review

Clear process descriptions on the monitoring of project management risks do not exist for the knowledge of the author. The realization of the project-internal monitoring process is in practice likely to vary between projects.

The implementation of project-external monitoring and review processes and the definition of their responsibilities would provide a tool for improving the project RM in individual projects. E.g., ISO 31000:2009 proposes the use of the progress in implementing risk treatment plans as a performance measure.

4.3.4 Summary of the recognized framework development possibilities

The FTA waterway project RM practice was recognized to have the following possibilities for development:

1. Integration of project (and process) management RM into organizational processes, including the FTA process management system and the project management and tender guidelines.
2. Design of waterway-specific hazard checklists.
3. Uncertainties about the risk, its analysis, and the treatments capability of reducing risk could be more explicitly assessed.
4. Development of the mechanism for risk information flow between projects and from historical data (e.g. through the use of information source checklists in the project launch).
5. Implementation of RM training programmes for project management (if such do not exist)
6. Improving the sufficiency of RM resources in waterway projects.
7. Complementing the RM guidelines in relation to conducting "communication and consultation", "establishing the context", "risk evaluation", and "risk treatment".
8. Introducing monitoring and review processes for project RM, regarding project management related risks.
9. Designing processes for using the risk and safety register (TURI)
10. Pairing the use of checklists with more imaginative risk identification techniques.
11. Improving the risk analysis approach with risk matrices with 1) information about its limitations, 2) introduction of more objective risk metrics alongside the matrix, and 3) the inclusion of positive risks.

While the list above is not expected to be complete, it does provide a number of development ideas for the FTA waterway project RM framework. Of these ideas, the following were chosen as the basis for the development of constructs in the frame of this research: 1, 2, 3, 7 (partly), 10, and 11. These constructs are described in the following section.

4.4 RM constructs and validation results

4.4.1 A RM process tied into the lifetime of waterway projects

Construct description

The construct consists of three individual processes, each describing the process of RM in a type of waterway project. These include full-scale construction projects (*Figure 11*), care and use service agreements (*Figure 12*), and comparably smaller maintenance projects (*Figure 13*). The RM processes for the construction and care and use projects are somewhat unambiguous in comparison to the process for small

maintenance projects; the maintenance project process descriptions includes a three-category classification of the significance & RM approach combinations for the maintenance projects. This stems from the great variability between different maintenance projects, which cannot be easily described with a single process. A similar classification is in use by the California Department of Transportation (Caltrans 2012).

The value of the construct is that it describes how the risk management process should be conducted in the course of projects on a general level. No explicit descriptions of these processes were previously available in the FTA. While the constructs are not likely to represent the best possible RM processes, it provides an initial level of descriptions, which could be eligible for their implementation in practice. Ideally, their functionality would be monitored in the course of future projects, and they would facilitate continuous development by describing "best practice" approaches at the FTA.

However, to fulfil the corresponding principle of the ISO 31000:2009, the processes should eventually be integrated as parts of the FTA process management system and the FTA tender guidelines.

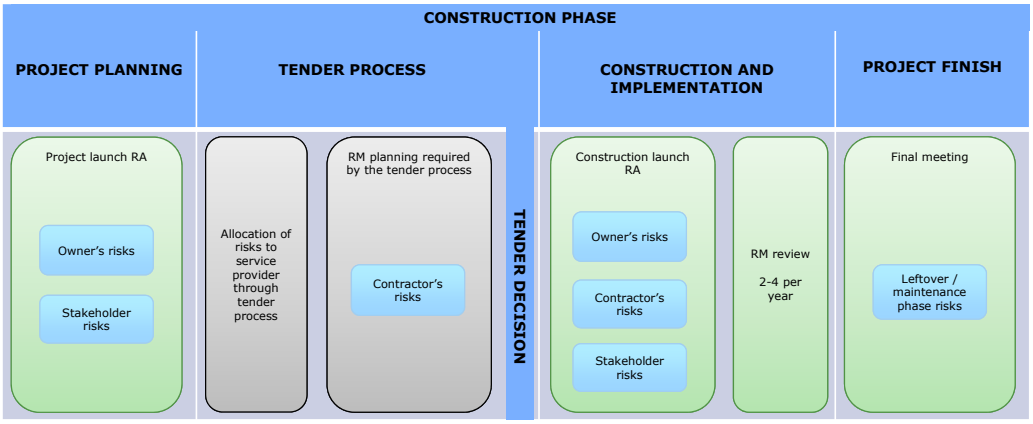


Figure 11: The RM process tied to the lifetime of a construction project.

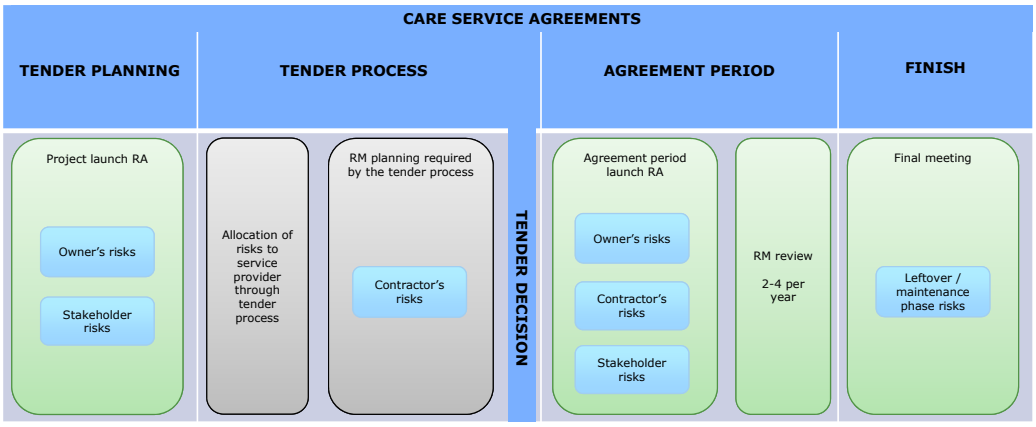


Figure 12: The RM process tied to the lifetime of a care service agreement project.

The process descriptions mostly follow the same structure: first, the risk assessments are conducted before the tendering process. The risk management plan is updated during the construction or project execution, and in the end of the project the successfulness of the risk management is evaluated and the remaining risk defined. The process descriptions have been adapted to fit the properties of each project type and corresponding terminology.

The process description figures proceed from the left to the right. The green shapes represent risk assessment, blue shapes the risks inflicted to the project, which have been identified, assessed, and described in the risk management plan. The grey shapes represent other risk management activities, such as the allocation of project risk to the service provider through the tender process.

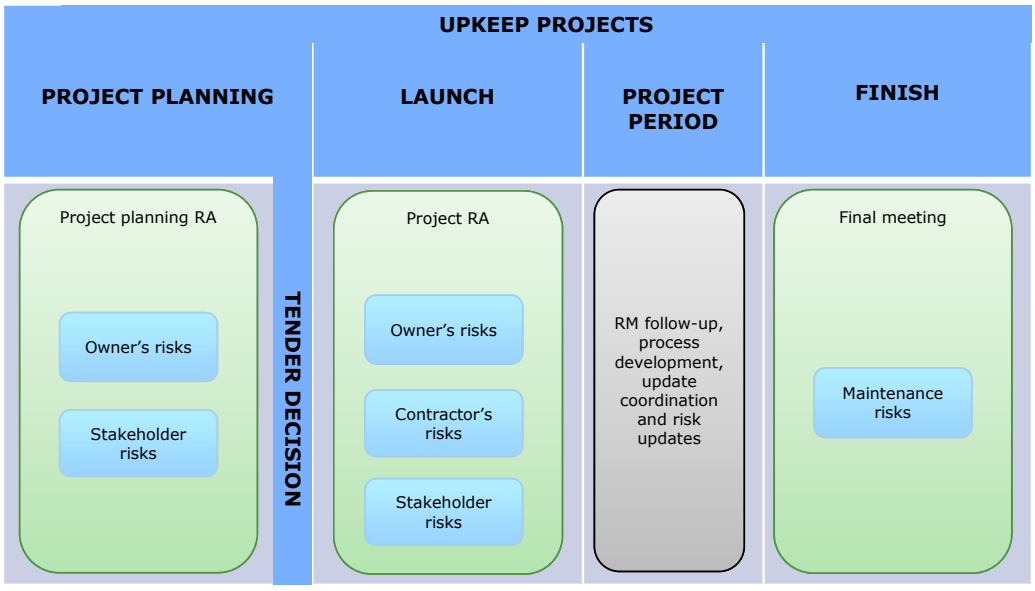


Figure 13: The RM process tied to the lifetime of an upkeep project.

The complete descriptions or legends for the processes can be found in the The constructs.

Construct validation results

The project RM process was commented and developed by two groups of experts in the FTA: by the participants of an expert workshop arranged for this purpose only, and by a process development group responsible for waterway management in the FTA. The construct was presented as such, without commenting on the future form or use of the constructs.

The response from the first expert group was uniformly positive, although some details in the processes required further development.

The latter meeting was not participated by the author of this work, and the "silent approval" transmitted as second-hand information may represent a biased piece of information. Additionally, the group is only responsible for waterway maintenance, and thus one of the three described processes in the construct was outside the group's interests.

Together, the commentary on the process could be seen to represent a tentative positive result from a weak market test.

4.4.2 Waterway specific hazard checklists

Construct description

Three hazard checklists were designed, each covering a certain part of the risks encountered in waterway projects. The checklists were given the titles Project management, Construction, and Maintenance. The idea of application was for all of the projects to cover Project management, and then Construction and Maintenance checklists were to be covered based on the project.

The checklist structure was based on Liikennevirasto (2010). The Project management checklist was adapted from Liikennevirasto (2010) to include waterway terminology and tender process risks, while the Construction and Maintenance checklists were created from the scratch, based on the semi-structured interviews, available risk management plans from relevant projects, and the available FTA waterway guidelines.

The Project management hazard checklist included hazards relating to e.g. contracting, regulations, the society, and information flow – elements which are present in some form in every waterway project. The hazards included in the waterway Construction and Maintenance checklists were assumed to concern different types of actions or functions required to be made in the course of waterway projects. These included for example the dredging and quarrying functions for construction projects and the different types of operations that are conducted to the sea marks in maintenance projects. In addition, certain elements were found to cause uncertainty to all types of projects. These elements included e.g. weather- and ice-related hazards, waterborne traffic hazards and technical hazards, such as equipment failure.

In addition, the use of the checklists was combined with the use of brainstorming before the checklists, to enable a more imaginative identification process in accordance to the ISO 31010:2010.

The whole set of hazard checklists can be found in the The constructs.

Construct validation results

All the checklists were given positive feedback in the expert workshop, although the maintenance checklist did face more changes than the project management or the construction checklist. The amount of risks identified in the case studies per hazard checklist is described in *Figure 8*. The number before the plus describes the number of recognized threats, and after the plus the number of opportunities. E.g., the figure "11+4" should be read as "11 threats and 4 opportunities". The use of all of the checklists was preceded with a short brainstorming session, and the numbers described in *Table 9* include the risks encountered through brainstorming.

Table 9: The number of identified risks in each of the case studies through the use of hazard checklists.

Number of identified risks through the use of the hazard checklists	Case A	Case B	Case C
Project management	**11+4**	n/a	n/a
Construction	**11+5**	n/a	**6***
Maintenance	n/a	(12+4)	n/a
Previously identified	**21**	n/a	**12****

*Additionally, five health and safety risks were updated.
**Includes only the risks concerning the waterway part of the project

The precise effect of combining brainstorming with the use of checklists was not analyzed after the case studies. However, it was perceived as a good addition to the checklists by some of the participants, and did in every case study collaborate with at least one risk that would have otherwise been left unidentified.

The project management checklist was tested only in the Case A, and having been previously (before minor modifications) in use in road and rail projects in Finland, its general usefulness well established, and the testing of the checklist was not as profound as with the other lists. The checklist redeemed comments such as "this should have been taken into consideration way before in this project", which speaks for the usefulness of the checklist. The checklist was also requested by the Case C project management, narrating a demand for the list.

The construction hazard checklist was tested first in the Case A project, and then in the Case C project, in which the waterway played a significantly smaller role. This was also reflected in the numbers of new identified risks (see *Table 9*). However, as the Case C project was only approaching the tendering phase, some of the identified risks caused immediate need for action, and even if only to ensure that certain details exist as expected, the practical collaboration of the hazard checklist was evident.

The maintenance checklist, on the other hand, did not appear to serve its purpose as well as the other checklists. Instead of facilitating conversation about the risks, it ended up facilitating the adjustment of the very checklist to more closely comply with the FTA hierarchy of waterway maintenance terminology. As a consequence, all the risks identified were a result of the brainstorming technique, and the checklist was developed after the case study.

The cause for the low result of identified risks using the maintenance checklist allows several hypotheses, which could true simultaneously or separately. Firstly, the checklist might have indeed been so faulty, that it drove the concentration away from the project in question. Secondly, the result might have been affected by unsuccessful facilitation and preparation of the participants. Thirdly, the contractor and the FTA project management had a long history in the industry, and thus had learned to

navigate the minefield well enough to not see the any significant uncertainty in the project at all.

But what appears equally possible, is that the perceived risks from a project's success perspective during a waterway care and use service agreement contract period simply do not contain the potential for the project to truly fail. This was further indicated by the comment about the RM plan: "It's important that the paperwork is in condition. But what really matters is how to transform it into risk-informed actions of the men at sea, not the red tape." A possible explanation is that the risks concerning the service during the contract period are completely transferred to the contractor, resulting in the risks and their treatment mostly being private trade secrets. Either way, this allows speculation on whether the risk assessments are useful at all from the FTA's perspective during the contract periods of the agreements.

4.4.3 Opportunity management as a part of RM

Construct description

It is widely recognised in the field of project management research that project RM should focus on both threats and opportunities (Atkinson et al. 2006, De Meyer et al. 2002, Hillson 2002). The natural tendency is to focus on the negative, resulting in even obvious opportunities to be overlooked, or at best addressed reactively (Hillson 2002). Thus, the inclusion of the management of opportunities was seen as a possible way to focus the project management's attention to opportunities in addition to the threats.

However, even though the management of both opportunities and threats is generally seen as better than just managing threats, the literature acknowledges that the explicit management of uncertainty would be even better. This is further discussed in Section 5.2.

The management of opportunities was included in the FTA RM process through the inclusion of three positive elements in the different parts of the RM process. Firstly, the identification process was complemented in the brainstorming technique by the requirement to include an equal amount of positive and negative uncertainties affecting the project. Secondly, the hazard checklists were reinforced with checkboxes for "opportunities" (see *Table 10*). And thirdly, the risk matrix was expanded with a positive axis for the consequences; resulting in a 5 x 10 matrix instead of the preceding 5 x 5 FTA risk matrix. The risk matrix can be found in the The constructs.

Table 10: The hazard checklist structure modified for opportunity management.

1.1	Contracting and resposibilities	Opportunity	Threat	No risk	To be resolved
1	Assignment contents				
2	Resposibilities and their allocation				
3	Contract interfaces				
4	Changes/additions in contracts				
5	Warranties, insurances				
6	Conflict resolution				
7	Work quality defects				
8	Quality assurance				
9	Responsibilities for plans and their quality				

Construct validation results

The idea of including a positive dimension in the risk matrix got positive feedback in most of the testing occasions, as it shifts the risk identification process towards the opportunities. Some comments were expressed before the case studies, doubting the occurrence of opportunities through the RM process. Yet the numbers in *Table 9* are clear: opportunities were identified as a part of the RM process, although their amount was a fraction of the identified threats.

The risk rating of the identified risks was high, more than half of them receiving risk rating of 3 or higher (interpreted as "moderate" and "demanding action"). However, despite the apparent good results, the author was left with the impression that most of the identified opportunities might not lead to any managerial actions or changes, and thus the actual average quality of the identified opportunities might be worse than what the numbers proclaim.

4.4.4 Modified FTA risk analysis process

Construct description

While the construct described in Section 4.4.1 describes the whole process of RM taking a general-level approach, this construct looks into its sub-process of risk analysis. The risk analysis process was enhanced through two changes to the risk matrix and the corresponding RM form:

1. The requirement of including an interval of possible consequences in the risk management form, instead of a simply choosing a single consequence category.
2. The inclusion of a parallel percent values in the risk matrix probability scale

The first enhancement contributes to the uncertainty and explicitness of the risk values. A 90 % confidence interval for the consequence could likely be appropriate for the analysis process, along with a half-day confidence interval training for all participants as proposed by Hubbard (2008). However, for the use in this study, a specific confidence interval was not defined.

The second part of the construct was a controversial, additional scale of probabilities in the risk matrix, in a way that in did not even closely match the original probability scale. Its primary purpose was to produce a comparison point for the original probability scale and to produce discussion about the probabilities of the risks.

The risk matrix can be found due to its size in the The constructs.

Construct validation results

The testing of this construct was perhaps the most controversial part of the validation process, and the testing process brought up results that were not expected prior to the case studies.

The use of currency-scale interval for the possible risk consequences was discussed and, in part, tested in one of the cases. Initially, it was commented that it would not be possible to determine any interval for the consequences, but when given a rough proposal for the interval, the adjustment of the numbers towards a reasonable estimation was suddenly found possible.

However, the client organization appeared reluctant to discuss the exact numbers concerning the possible consequences of the risks. When stressed, they commented that the discussion of the numbers might prove useful, but this should be done internally to the client organization, without any external service providers – indicating that the information were too sensitive for the ears of others – while risk information based on the analysis with risk matrix were not.

The client organization representatives of another case, on the other hand, approved the idea of analyzing risk consequences with intervals, with a statement claiming that all additional information is useful.

The second part of the construct, the inclusion of non-matching percent values on the probability scale of the risk matrix, was tested in each of the case studies, after being deemed reasonable for testing in the expert workshop.

The inclusion in the matrix was typically acknowledged by the case study participants with a single remark, but no other comment was expressed during or after the case studies, or when commenting the results. Thus, no effect was detected to have been caused by the enhancement. This consequently indicates that the actual values on the probability axis of the matrix play no significant role in the risk analysis process using a risk matrix. This controversy provides reasonable doubt that the use of the risk matrix would generate results with practical usefulness – or that the potential for making accurate conclusions about the ALARP level of the risk based on the matrix analysis alone were possible.

Rather, it appeared that the use of the risk matrix was based more on the risk classes than the probability-consequence scale. This was reflected during and after the case studies in comments such as “We think this risk should be level 3 instead of level 2”, or “We can’t give a level 5 to it. They’d look at us badly in the RM department, without understanding the true nature of the risk.”

Should this hypothesis about the low level of information of the matrix-evaluated scores be true, it would contradict with the FTA RM Principles (Liikennevirasto 2016d), which requires the risks and their treatments to be analysed in a way that allows direct comparison of the RM resources and the corresponding gains. While it should be noted, that one cannot definitely declare how this observation would affect the project results compared to a more specific analysis method, it appears clear, that the expertise and the experience of the service providers and other stakeholders cannot be utilised in full extent in the RM process or risk-related decision making when only using a risk matrix in the risk analysis.

4.4.5 Model for establishing a project's RM process context

Construct description

A simple visual tool, a model or a form, was created to provide a simple way for establishing the context of a RM process. Its idea is to depict the different aspects to be covered by the RM process, and it should be prepared for each RM process individually.

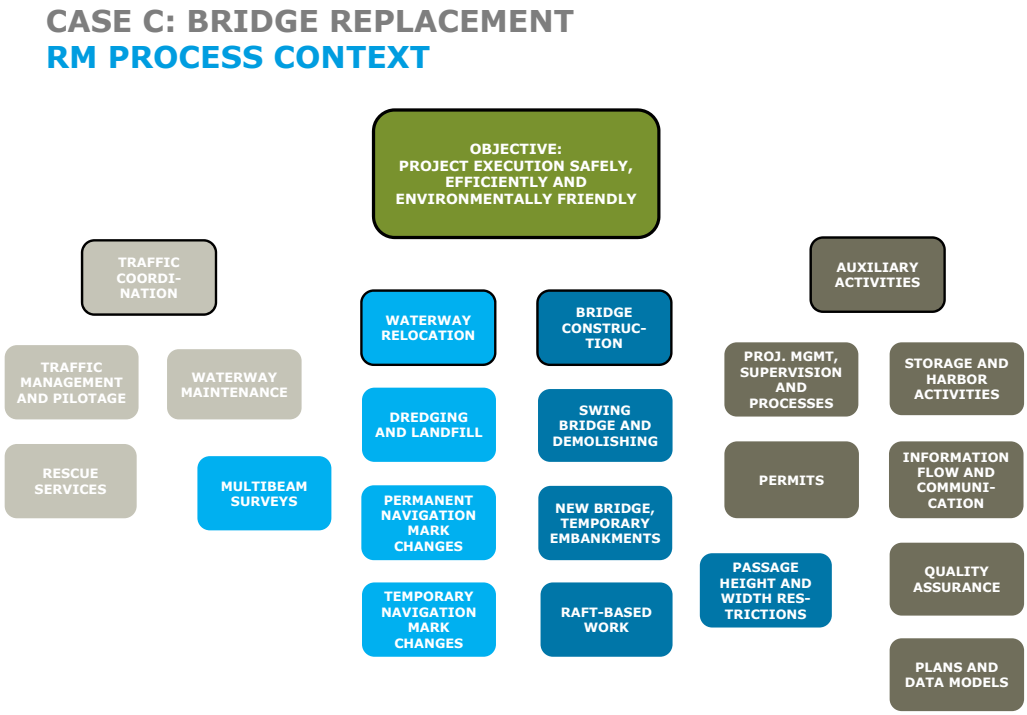


Figure 14: An example of the model for establishing a project's RM process context.

Establishing the context is described as the first part of the FTA and ISO 31000:2009 RM process. However, it should be noted, that the construct does not cover the whole "establishing the context of the RM process", as described by the ISO 31000:2009, but rather focuses on describing the project objectives. Of course, the construct can be used in various ways depending on the project and risk management approach, but its value is in its ability to present project variables in an easy and visual manner.

Figure 14 describes one example of the model, while two further examples can be found from the Appendix A6.3 Model for establishing a project's RM process context.

Construct validation results

The model for establishing the context of RM was perceived as useful and appropriate for composing the scope of the project for the use of the RM process. It was in all case studies silently accepted as the basis for the risk assessment, although its level of use varied between projects. Especially the participants external to the project organizations seemed to benefit from the construct.

4.4.6 Summary of the validation results

Table *11* summarizes the construct validation process results. The results concerning the use of project management and construction hazard checklists, and the form for establishing the context for the RM process are clear: they were proved in practice and seen useful by the practitioners.

Table 11: The validation results of each developed construct.

Validation results per construct	Weak market test	Risk identification results
1. Waterway project RM process	x	n/a
2. Waterway hazard checklists		
- project management	x	x
- construction	x	x
- maintenance	x	½
3. Opportunity management	x	½
4. Modified FTA RA process		
- consequence interval	½	n/a
- dual probabilities in matrix	n/a	n/a
5. Model for establishing project RM context	x	n/a

The maintenance checklist was seen useful as well, although the practical use of the checklist along with the corresponding project RM process description would require further discussion, development, and testing, before taking on a full-scale implementation into the FTA processes and guidelines. One possibility for the development of the process would be to apply it to the combined, yearly tender preparation phase of all the maintenance projects instead of the application to individual maintenance projects.

Equally, the other project RM process should go through further development before implementation, but they appear to be somewhat better founded as such, based on the positive experiences from the case studies relating to construction projects.

The management of opportunities as a part of the RM process was a well-received construct. Although the quality of the identified opportunities in the case studies per se is questionable, the potential of switching the project management's mind-set towards the positive weighs on the other end of the scale. This would reflect the comment of the FTA's Swedish counterpart about "getting to the offensive side" of RM.

The results and reception concerning the modified FTA RA process were less impressive, implying that more research and development work is needed for the application of the construct in practice.

5 Discussion

5.1 The problem of determining the correct path for RM

The success or failure of a RM approach in either enterprise or project context – or both – is a result of a complex interplay of factors relating to an activity. Therefore, one cannot make definite conclusions about the successfulness of an approach in an activity based on the experiences from another activity. The same problem applies to "best practices" of RM, and to the constructs developed during this research – they do not necessarily work in other contexts than which prevailed during the initial experiments.

However, from this follows that the approach which was initially applied to a context is rarely the best one in the next context. This could firstly mean that the experimenting with different methodologies in different contexts should be a constantly ongoing process. Secondly, this could mean that instead of describing a "best practice" approach, a toolbox containing a variety of RM approaches and their success in varying contexts might be more useful.

The creation of such toolbox at the FTA would, of course, inflict its own demands – at least two of which require changes in the current project practice: first, the monitoring and measurement of different levels of RM processes and their successfulness should be enhanced, possibly according to the guidance of ISO 31000:2009. The practice-based definition for ERM by Mikes & Kaplan (2014:14) points towards the same direction with their requirement of [successful] ERM consisting of *"active and intrusive processes … capable of challenging existing assumptions"*. Second, the RM sub-process of *establishing the context* should be brought to a level, which allows for the other project risk managers to use that information for choosing their approach.

Without the information provided by such a toolbox, the use and development of project RM approaches inside the FTA can only be based on intuition and heurestics about the practice and on incomprehensive information from single case studies.

This is partly what was done during the course of this research. The next three sections below describe some hunches along with reasoning on potential development directions for the waterway project RM at the FTA.

5.2 Towards the management of uncertainty

The construct introducing the management of opportunities in addition to threats provides one step towards the management of risk as it is defined in ISO 31000:2009: "the effect of uncertainty on objectives". However, the use of the construct does not quite reach the target of managing uncertainty, but rather dodges the question.

Atkinson et al. (2006) argue that even though RM of both threats and opportunities produces better results than only focusing on the negative, the approach still falls short: *"It does not facilitate consideration of aspects of variability that are driven by underlying ambiguity and lack of information."* Effective uncertainty management needs to address uncertainty in a broad sense, with the consideration of all sources of significant uncertainty and associated responses, such as the lack of information, ambiguity, characteristics of project parties, trade-offs between trust and control mechanisms, and varying agendas in different stages of the project life cycle.

A more explicit focus on uncertainty management is required. This can be facilitated by paying attention to the involved parties and their respective objectives in three ways (Atkinson et al. 2006):

1. Treat the definition of objectives as a key part of managing projects
2. Project management should clarify and manage desired trade-offs between multiple performance objectives
3. Ownership of uncertainty requires specific consolidation – decisions need to be made about how uncertainty and associated issues should be allocated to the different parties, recognising that different parties have different objectives, perceptions of project risk and different capabilities for managing associated sources of uncertainty.

However, in order to switch the focus onto the uncertainties instead of the threats one must account for the method of their measurement, or risk analysis. Although in some cases the matrices might provide a good medium of measurement, a more intuitive way could be found from the use of intervals, or probability distributions (see e.g. Modarres 2006), which make it possible to describe the inherently probabilistic information in an unambiguous way. For example, using a risk matrix to analyse a risk with both positive and negative consequences would require choosing a value from both the negative and the positive axis, leading to a very unintuitive description of the risk.

Nevertheless, the use of risk matrices is very established in the FTA, and if this approach for risk analysis were truly dysfunctional, it would likely have been substituted with a better solution already during its implementation process. This could be explained by the historical development of RM in Finland, where it was first implemented during the 1980's and 1990's in safety, environmental, and quality contexts (Räikkönen 2002:13–20); it is notably more difficult, or less intuitive to identify risks with positive safety or environmental consequences, and thus generating adequate methods and tools for their management can be considered significantly less fruitful. One could imagine that after the risk matrices were found useful in their initial context, they were simply migrated into the use of more general project RM without diligent checking for compliance, the result of which is the concurrent FTA project RM approach.

The prevailing ambiguity of risk information in the Finnish project RM could also be explained through effectivity and efficiency. Lehtiranta (2014) describes similar phenomena regarding the uninformativeness of risk information as discussed in Section 4.4.4: *Modified FTA risk analysis process* in her case study about the project RM in a complex Finnish construction project: "*The activities involved in the identification and analysis of risk are in practice intertwined. Risk analysis in the case*

projects is often intuitive, and the main assessment is simply made between the qualitative categories, 'significant' and 'insignificant'. … The identified [RM] processes seem to be more based on heuristics and intuition than on calculative analytics". She seems to suggest this could be at least partly a result from the pursuit for effectivity and efficiency in the construction phase of projects, in which case the relative lack of information could be a by-product of using a two-dimensional matrix for describing information which by nature would be well represented by the two categories: significant and insignificant.

In either way, or even if neither were true, a conscious decision should be made about the level of information which should be pursued by the risk analyses in the FTA waterway projects. In making this decision it should be acknowledged that one problem with relying on heuristics and intuition is that they only serve well in environments in where the decision maker has had the ability to learn and adapt their mental models from previous projects or phenomena in an environment which is sufficiently regular to be predictable (Kahnemann 2011:234–244).

5.3 Mutual trust and the contracting model

Atkinson et al. (2006) underline the importance and development of mutual trust in well-performing projects, especially when the project contains significant uncertainties. This was equally stressed by an interviewee from Sjöfartsverket, who described their "best practice" of a multi-day kick-off workshop in the beginning of each project, where project objectives and risks are discussed between the participants, and mutual trust is developed. *"Usually 80–90 % of the [stakeholder] objectives are, in fact, the same"*, helping to provide a solid surface for mutual trust without changing the contract.

Yet there are projects, where the participant objectives simply are not the same, and the development of mutual trust and open discussion of uncertainties inevitably results in one or more of the stakeholders abusing that trust to their own benefit. According to the Sjöfartsverket interviewee, in these cases an open RM process is not the correct tool for project success. Instead, the interviewee had personally seen the positive change brought by [public-private] partnering contracts, which, if used correctly, aligns the stakeholders' goals and enables a good working environment for RM.

The validation results indicated a restraint of the communication of quantified risk information between the parties of a project. This hindered the risk analysis by firstly removing the contractor's experts from contributing to the project RM from their perspective, and secondly, in the case example, also implied that the use of the more precise risk analysis methods was not applied in the risk analysis. Whether this in fact was affected by lack of mutual trust is unclear, but the hypothesis should not be disregarded either.

A possible redemption would be to create and nurture a climate of mutual trust among the project participants. Also, following the example of Sweden into the use of partnering contracts is a noteworthy possibility.

5.4 The next steps for FTA

The current FTA waterway project RM framework is in practice a one-size-fits-all approach for safety and health risks, falling short from the standard it refers to in a number of ways. Although, under the contingency theory, it is not evident that the ISO 31000:2009 standard would provide the best possible framework for waterway project RM, nothing was found to point toward the standard not being adequate in this context.

Instead, the author recommends the FTA to continue with the implementation process of the standard (assessed in Section 4.3), while respecting the complexity and needs of single waterway projects. For the use of the constructs, the first steps could be to apply the developed hazard checklists into practice, and to include and develop the project RM processes as integral parts of waterway project process descriptions and tender guidelines. The subsequent step could be to tilt the RM plane toward the management of uncertainty instead of focusing on threats and opportunities alone, and to establish a project start workshop practice along the footsteps of the Swedish (see Sections 5.2 and 5.3).

During the course of this research, one development idea surfaced continuously: the RM in the planning phase of waterway projects is inferior if not completely lacks existence. To provide a reliable basis for decision making in projects, and a natural flow of risk information from planning to the construction phase, the RM processes and approaches in the waterway planning phase need to be developed. The ISO 31000:2009 standard could provide a good starting point for the work, while e.g. the project RM manual of California Department of Transportation (2012; and Maria-Sanchez 2012) might enable adequate benchmarking.

Another idea worth considering would be to create a "common body of knowledge" containing the RM tools, approaches and structures that can be used in varying applications and projects throughout the FTA. A wiki-like structure could enable the managers and project managers to rate and comment the different practices based on their experiences, and describe the RM approaches they perceive to be most adequate.

5.5 The reliability and applicability of the results

The reliability of the results varies between the different parts of the thesis. Some conclusions are backed up by the survey, the interviews, the RM framework analysis and the validation process of the constructs. These represent a very reliable level of information. In the other end of the scale of reliability lie the subjective interpretations made by the author based on the single case studies.

Especially the results of the FTA waterway RM practice evaluation in Section 4.3 represent a fairly subjective and shallow understanding. Thus, instead of seeing the results as an absolute statement, the value of the evaluation is the evaluation results and their ability to provide development possibilities leading to successful constructs.

Special consideration should be applied to the reliability of the validation process results. The sample of the study was relatively small, and although it represented some of the largest waterway projects being conducted during the work, the majority of different projects and project types were left outside the case studies. Thus, even if the constructs worked in the given environment, they might severely lack functionality in another.

The validation of constructs through market testing included the simplifying assumption that the FTA project management have a collective ability to adapt to managerial circumstances and new ideas. However, this is not necessarily true. The FTA as a public service provider does not compete on the market, and thus the existence of forces inflicting positive change in the efficiency and efficacy of the management practices is not self-evident, but rather a question of government policies and political willpower.

But perhaps the most significant factor affecting the result reliability is the author's biases and perceptions. The share of the author's participation and subjective interpretation throughout the validation reporting is notable, and neither objectiveness nor the lack of biases can fully be guaranteed.

The applicability of the constructs outside of the Finnish public sector waterway projects is limited, although possible. There is no good reason to expect construct functionality outside their proper context; only through understanding the constructs' initial environment should the constructs be adopted. However, at least some of the results should be applicable to the other types of waterway projects run by the FTA. These projects are conducted using partly the same guidelines and other RM framework items in a similar cultural and legislative environment as the studied waterway projects.

5.6 Theoretical connections and contribution

The conducted research has its roots in the contingency theory of ERM. The results suggest that the ISO 31004:2013 could provide an adequate basis for the analysis of the "ERM mix" in those organizations, which have implemented or are guided by the ISO 31000:2009 standard for RM.

This work describes one ERM mix combined with a group of contingent variables. As it will require a significant amount of additional data to determine the best variables for forecasting the successfulness of a RM approach, it cannot be known for certain whether this research contains all of them or not. To counter this effect, this analysis made in this thesis tries to capture a variety of factors affecting and describing the RM process.

The validation results of the developed constructs indicate that hazard checklists combined with brainstorming approach provides a functioning tool for the risk identification in waterway development projects in the Finnish waterway projects. The rest of the validation results provide less coherent information on the performance of the available and developed RM tools and approaches. The practical functionality of the other constructs should be observed over longer periods of time.

The results described in this thesis could be utilised in the development of a "common body of knowledge", as described by Mikes & Kaplan (2014).

5.7 Recommendations for further research

The development of a common body of knowledge consistent with the contingency theory would provide significant help to practitioners worldwide. As the practices for disclosing corporate risk information vary, and often reflect the most ambiguous and non-comparable information possible, the risk information available from the corporate sector is minimal (Hookana-Turunen 2000). Thus, the public sector could play a significant role as the source of the information for the development of an established body of ERM risk knowledge – which could be especially beneficial in a small market like Finland.

On the other hand, a crucial research possibility in terms of the credibility of project RM would be the development and eventual implementation of such RM tools and practices, which allow risk analysis to be conducted unambiguously while not compromising process efficiency. Borrowing from Lehtiranta (2014): "*Research should rather be concerned with understanding and supporting the mechanisms of assessing what type of uncertainty matters and how to identify and manage it. Alternatively, the finding can be taken as a challenge of identifying or innovating the quantitative techniques that would, in fact, fit into the project practice, resulting into less biased and more easily visualized risk information.*"

6 Summary and conclusions

A constructive research approach was taken upon to clarify and develop the Finnish Transport Agency's waterway project risk management (RM) framework. Relevant preunderstanding on the subject was gathered from the literature, and through expert interviews and an expert survey. Based on the preunderstanding, the FTA waterway project risk management framework was evaluated following the technical report ISO 31004:2013, which describes the implementation process of the RM standard ISO 31000:2009. The evaluation of the framework allowed analysing the FTA RM practice in a structured and clear manner.

The findings suggest that the focus of the FTA waterway project risk management has been in safety and health risks, while the risks affecting project objectives have not been given due attention. While the FTA guidelines for RM call for the management of risks affecting project objectives, the practice has not followed. Instead, the FTA waterway project RM framework was found to contain several deficiencies, which can be claimed: e.g. the lack of adequate tools, process descriptions, resources, and commitment for managing risk.

Based on the identified development possibilities, the following risk management tools and processes were developed and validated though case studies and user group testing:

1. three risk management processes tied to the structures of waterway projects,
2. three hazard checklists,
3. the inclusion of opportunity management,
4. the enhancement of the risk analysis process, and
5. a model for the establishment of the context of the risk management process.

The results of the validation process suggest that the developed risk management tools and processes could be partly taken into practice as such, while some items should be further developed and discussed. On a larger scale, the developed RM tools and processes and their validation results appear to significantly improve the FTA waterway RM framework.

Based on the findings, the management of risks affecting project objectives could be more fruitful when perceived as "uncertainty management" instead of looking for threats and opportunities. Even if the management of threats were a more intuitive way to manage safety risks, it seems counterintuitive from the point-of-view of managing risks to project objectives. Furthermore, the weaknesses of the current risk analysis methods should be acknowledged by the practitioners, and the possibility to make conclusions based on these methods should be discussed internally at the FTA.

In the long term, the development and monitoring of RM inside the FTA should be systematic, and could for example include project personnel to develop their commitment. And from the projects' perspective, the most beneficial RM process requires mutual trust between the project participants. The development of trust could be emphasized through, e.g. kick-off workshops or alliance contracting.

The level of RM described by the ISO 31000:2009 standard appears at least partly worth pursuing in waterway projects, while the ISO 31004:2013 technical paper describes a seemingly good structure for analysing and developing the RM framework.

These results are expected to be valid in the Finnish waterway projects run by the FTA, and up to some extent in other types of FTA transport infrastructure projects. Yet it is likely, that any waterway project in the northern parts of the globe would be affected by similar risks, and thus some parts of the results or developed constructs may be applicable outside Finland. However, the reliability of the results is affected by the limited amount of data along with the subjective of interpretation of the results.

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Waterway classification in Finland

The FTA waterway classification

Adapted from Liikennevirasto 2013

MAIN CLASS			WATERWAY CLASS		
1	Maritime commerce waterways	A waterway built and maintained primarily for maritime commerce. Maritime commerce is used here to describe coastal traffic that pays waterway fee. In the freshwater environment the Saimaa deep waterways are understood as maritime commerce waterways.	**VL1**	First class maritime commerce waterways	Nationally or areally significant maritime commerce main waterways, which are used to transport a significant share of waterway transport.
			VL2	Second class maritime commerce waterways	A maritime commerce waterway with mostly areal significance, or a parallel or connective waterway in the vicinity of a main waterway.
2	Shallow waterways	Waterways built and maintained primarily for boat traffic or other traffic excluding maritime commerce	**VL3**	Shallow waterways for utility traffic	Waterways serving e.g. ferry traffic, fishing ships, barge traffic, timber rafting and areally significant passenger traffic.
			VL4	Yachting main ways	A yachting main way, which forms a uniform, longer route on the coast or inland between two areas.
			VL5	Local yachting waterways	A local waterway, e.g. the route from a main waterway to a harbour or a connecting line between two waterways
			VL6	Yachting waterways	A low-level shallow waterways serving yachting

Summaries of waterway project RM guidelines in Sweden and Denmark

The waterway authorities in Sweden (Sjöfartsverket) and Denmark (Transportministeriet) were expected to be potentially relevant in terms of benchmarking their approaches of waterway project risk management. This was supported by the countries' relative similarity to Finland, and a good availability of information. These expectations were partly fulfilled in the frame of this research, and the summaries of the available documents are presented below. The information from the Sjöfartverket's interviews is discussed in detail in Section 4.2.3.

Sweden

The risk analysis process for the organization-level approach of Sjöfartsverket consists of the following three phases (Sjöfartsverket 2016):

1. Analysis of objectives and their sub-objectives. This also includes a screening of the strengths of dependencies between objectives (say, the availability of VTS services is a more important contributor to port activities than the communal rescue service).
2. Risk identification concerning the predefined objectives.
3. Risk analysis and risk treatment. The risks are first divided into the classes of sustainability (environmental, social, economic), and then analysed with a semi-quantitative risk matrix with scales from 1 to 4. The risk analysis approach is fairly similar to the FTA approach.

The result of the process is a risk analysis report, similar to the FTA spreadsheet.

Denmark

From the perspective of financial steering of infrastructure projects, the Danish Ministry of Transport divides the projects into 5 phases (Transportministeriet 2010):

1) Preliminary research and consequent decision making
2) Proposal for decision making and construction decision making
3) Detailed planning
4) Tendering
5) Construction and introduction

Even though this research considers only the construction and maintenance projects, the risk assessment methodology in the planning phases are shortly summarized here to provide a background for understanding the steering in the latter phases. It should be noted, that based the Transportministeriets document (2010), risk and financial governance should be regarded as tightly spun together. This enables a better level of financial forecasting, and the possibility for the Danish Ministry of Transport to see the whole picture of risks in their different projects. On a practical level, the budget takes financial risk into account on both the project level and on the level of single risks.

In phases 1 and 2, the financial and the risk management plans are reviewed by an external operator, which focuses on the "weak points" and the feasibility of the project plans. From the decision making's point of view, the assumptions made in the budget are explicated, and the consequences of those assumptions not holding true are clearly stated.

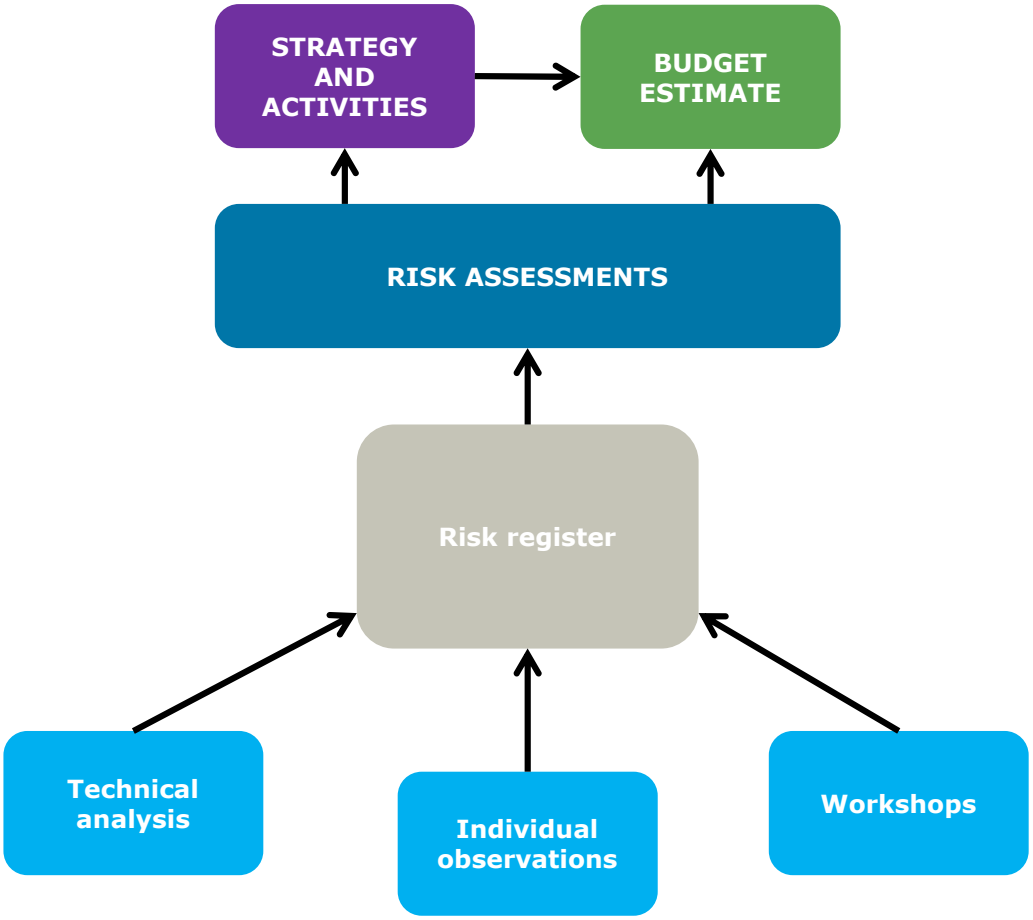


Figure 15: A flowchart describing the risk management process of a single project (Transportministeriet 2010:25).

The Figure 15 describes the risk register management process in the Danish transport infrastructure projects, and depicts how the identified risks affect the project budget, and how risk assessments are seen as separate from the risk register.

During a project's construction planning, tendering and introduction (phases 3-5), the project status is reported twice a year, including the development and updates in the project's risk register. Formal risk assessments are conducted with similar intervals, with regard to the project status report. (Transportministeriet 2010:30–36).

From the safety, or navigational risk perspective of all the waterway projects in Denmark, both in public and private projects, the planning phase risks are assessed based on a specific assessment form by Soefartsstyrelsen (201Pha3). In the case of larger construction projects, the Formal Safety Assessment by the IMO (2002) can be required (Soefartsstyrelsen 2016a). On the practical level of identifying risks and their potential treatment methods, the hearing of seafarers and related authorities is included as a compulsory step of the Soefartsstyrelsen's (2016b) permit process.

Interview Questions

The following questions were discussed during the semi-structured interviews:

1) Preliminary information:
   a) Job label
   b) Short description of tasks and work history
2) How familiar are you with risk management? In which kind of projects are you familiar with it?
3) What kind of tools have you used for managing risk? Do you acknowledge your affiliates to have used certain tools? (E.g. risk matrix, risk map)
4) Which guidelines and materials have you used for risk management?
5) Do you find that risk map, risk matrix and risk management plan are adequate tools for use in waterway project risk management? Why/why not?
6) What kind of benefits do you perceive that risk management brings/could bring to waterway projects?
7) How are these benefits measured or how should they be measured?
8) Has the information provided through risk management been systematically taken into account in decision making?
9) Do you find that your know-how in risk management is adequate, taken your position? What kind of things do you find challenging?
10) How does the risk management you have done in the projects of the FTA compare with the risk management conducted in your own business activity? (Not asked from the FTA, Sjöfartsverket or Trafikverket interviewees.)

Survey scoring methodology and survey form

The results and the general methodology of the survey are discussed in section 4.1.

A4.1 Survey scoring methodology

RM experience score (1–5)
The participants evaluated their experience of RM in six categories of waterway projects: planning, construction, and maintenance in both sea and freshwater environments. Each of these categories was evaluated on an ordinal scale from 1 to 5, with the explanations:

1. No experience
2. (empty)
3. I have participated in a risk assessment
4. (empty)
5. Is an essential part of my job description

The points of the categories were averaged for each participant, resulting in a "RM experience score" on an ordinal scale from 1 to 5.

Risk type score (1–3)
The evaluation of RM experience of different risk types was conducted in a similar manner as the RM experience score, but the ordinal scale for each category ranged from 1 to 3, without the empty categories in between:

1. No experience
2. I have participated in a risk assessment
3. Is an essential part of my job description

These questions were asked specifically with a requirement that the RM has had to be systematic, where systematic was defined as "the management activity being retraceable". However, it must be noted, that this requirement does not necessarily guarantee a RM approach that would comply with any standard, and also given that a "trace" can mean practically anything, the answers cannot be interpreted as to have practical relevance except for being compared with each other.

The evaluated risk types included the following: work safety, traffic safety, quality, environmental, economic, schedule, political, reputation and RM failure risk.

The points of the categories were averaged for each participant, resulting in a "risk type score" on an ordinal scale from 1 to 3.

RM benefits and drawbacks
The respondents were given a list of possible RM benefits as listed in the ISO 31000:2009, to which was added a statement about "facilitating project success", and a comparably shorter list of possible drawbacks due to RM. The respondents were asked to tick the benefits and drawbacks they identified with RM. The respondents were also given the possibility to write a benefit or a drawback of their own.

A4.2 Survey form

The form is a direct translation form the original, Finnish survey form.

RAMBOLL

Risk management in waterway projects

This survey strives to gather information about the current state of waterway project risk management, and development ideas for developing a common framework for waterway project risk management.

The survey will take approximately five minutes to complete.

The answers are confidential, and they cannot be matched to the respondent by others than the survey administrator. Additional information: oliver.heinonen@ramboll.fi

Thank you for your cooperation!

Next →

RAMBOLL

Risk management in waterway projects

Information about the respondent

1. The respondent *

Forename	
Surname	
District (of operations)	

2. Public or private sector? *

Answer based on your current employer.

- ○ Private, which company? _____
- ○ Public, which department? _____

3. Job description *

Tell with a few words about your:
1) job description
2) working experience in the planning, construction and maintenance projects in both freshwater and sea waterways

← Previous Next →

RAMBOLL

Risk management in waterway projects

4. How familiar are you with risk management in the following types of projects? *

1) No experience
3) I have participated in a risk assessment
5) Is an essential part of my job description

	1	2	3	4	5
Sea way planning	○	○	○	○	○
Sea way construction	○	○	○	○	○
Sea way maintenance	○	○	○	○	○
Freshwater way planning	○	○	○	○	○
Freshwater way construction	○	○	○	○	○
Freshwater way maintenance	○	○	○	○	○

5. Which of the following risk types have you SYSTEMATICALLY assessed and managed in the forementioned projects?

Systematic risk management leaves a document, which allows for evaluation of success afterwards.

Explanation:
1) No experience
2) I have participated in a risk assessment
3) Is an essential part of my job description

	1	2	3
Occupational health and safety risk	○	○	○
Traffic or other safety risk	○	○	○
Quality risk	○	○	○
Environmental risk	○	○	○
Economic risk	○	○	○
Schedule risk	○	○	○
Political risk	○	○	○
Reputational risk	○	○	○
Risk assessment or monitoring failure risk	○	○	○
Other risk, what:	○	○	○

6. What drawbacks do you believe are inflicted by a systematic approach on waterway project risk management? *

Take into account, that the drawbacks can affect in various kinds of waterway projects, and on an upper level.

- [ ] Increase in workload
- [ ] Increase of expenses
- [ ] Increase of useless bureaucracy
- [ ] Increase of requirements
- [ ] Focusing on irrelevant
- [ ] Weakening of information flow
- [ ] Deterioration of stakeholder trust
- [ ] Something else, what:

7. What benefits do you believe are inflicted by a systematic approach on waterway project risk management? *

Take into account, that the benefits can affect in various kinds of waterway projects, and on an upper level.

- [ ] Facilitating of carrying out projects
- [ ] Increasing the likelihood of achieving objectives
- [ ] Encouragement of proactive management
- [ ] Improvement in the identification of opportunities and threats
- [ ] Improvement in reporting
- [ ] Improvement in information flow
- [ ] Improvement in stakeholder trust
- [ ] Establishing a reliable basis for desicion making and planning
- [ ] Effective allocation and use of resources
- [ ] Improvement in operational effectiveness and efficiency
- [ ] Enhancement in expense control
- [ ] Enhancement in health and safety performance, as well as in environmental protection
- [ ] Improvement of loss prevention and incident management
- [ ] Improvement of organizational learning and resilience
- [ ] Something else, what:

8. Free word

Development ideas, tips and other thoughts are taken in very gladly!

← Previous | Submit

Summaries of the FTA RM framework documents and systems

The formal, partly public, partly FTA internal framework structure concerning waterway project RM consists of the following documents:

1. FTA RM Principles (Liikennevirasto 2016d)
2. FTA RM Protocol for transport infrastructure projects (Liikennevirasto 2015)
3. Safety risk management procedure for infrastructure projects (Liikennevirasto 2012)
4. RM in railway planning (Liikennevirasto 2010)
5. Risks in road care service agreements (Tiehallinto 2009)
6. The FTA process management system
7. Safety and RM register (TURI)
8. Internal tender and project management guidelines and contract forms

The documents 1–5 are publicly available to service providers. Systems and guidelines 6–8 are available to FTA employees and to service providers through agreements.

1. FTA RM principles (Liikennevirasto 2016d)

The document describes the RM policy; the objectives, principles, responsibilities and implementation of RM on the FTA level.

The following are listed as the objectives of RM in the FTA:

1. increase the likelihood of achieving objectives;
2. improve the identification and management of opportunities and threats;
3. improve governance;
4. establish a reliable basis for decision making and planning, and for allocating resources;
5. comply with relevant legal and regulatory requirements and international norms; and
6. secure funds and property.

RM should be transparent and comprehensive; the stakeholders in- and outside FTA should be included in the process. Internal communication increases risk awareness, helps to learn from the realized risks and to understand the made decisions throughout the FTA. The communication channels for risk include project meetings and the internal communication channels of the FTA.

The RM resources should be in relation to the expected gains. Taking risks should always be a well-considered, case-dependent decision, which requires evaluating the expenses of both the risk treatment option and the significance of the risk in a uniform manner. This enables comparing the risk and its treatment. However, risks affecting safety or environment should always be minimized and controlled.

Risks are classified to strategic, process and project risks, where the strategic risks affect the whole FTA, the process risks affect a certain process which usually encompasses a number of projects at once, such as the development of the waterway

network, and finally the project risks affect a single project, such as the Rauma harbor waterway deepening project.

2. FTA RM protocol for transport infrastructure projects (Liikennevirasto 2015)

The FTA guideline defines the risk management approach for infrastructure projects. It can be seen as the building block between the RM principles and the infrastructure-type specific risk management frameworks.

The infrastructure projects, to which the guideline is applied, span a great variety of projects when it comes to temporal, spatial or monetary figures. Thus, the guideline defines infrastructure project risk management in a fairly top-level manner, and refers to other guidelines and tools for application to specific infrastructure types.

The guideline lists four central principles of risk management:

1. Risk assessment is a part of the decision making, leading, planning and controlling of a project.
2. Confirming that the made decisions do not surpass the appointed risk level or risk management capability is a part of decision making.
3. The project actively reduces or removes risk through its own actions.
4. Accidents are prepared to with plans, which ensure an efficient delimitation of damage and quick repairing actions.

In addition to these, the guideline explicitly states a group of other principles for risk management:

5. Risk management is done consciously, and is planned and continuous.
6. Risk management has to span all of the risks and problems related to the different phases of the project.
7. The goal of risk management is to produce a safe product in a controlled manner.

The guideline divides infrastructure projects into the planning, construction, and maintenance phases, and describes the required safety and risk management documents in each phase. It lists risk types and existing FTA hazard checklists which are to be assessed in each project phase. These hazard checklists include the Safety risk identification procedure for infrastructure projects (Liikennevirasto 2012), RM in railway planning (Liikennevirasto 2010), and Risks in road care service agreements (Tiehallinto 2009). The hazard checklists are each a part of a separate risk management guideline or manual, but the use of both the checklists and the manuals can be adapted according to the project.

The requirements of transferring RM-based knowledge between projects and project phases are defined, although the practical procedures are not included in the document.

The described risk management process is similar to the one of ISO 31000:2009, and a short guidance for assessing risks through workshops is included.

The guideline defines “the essential tools of risk management”. These include SWOT-analysis, risk maps and hazard checklists, a risk management plan form and a risk matrix.

3. Safety risk identification procedure for infrastructure projects (Liikennevirasto 2012)

The Safety risk identification procedure for infrastructure projects, also known as the *INFRA risk map*, is a manual, to which is attached a risk management form, a risk matrix, and several hazard checklists with a risk map front page enabling a quick peek on a project's safety concerns.

The manual describes a risk management process in which the attached tools can be used, the descriptions for their application, the required documents in each project phase, and guidance for assessing risks through workshops, along with an example of participants of a waterway-related RM workshop.

The hazard checklists cover the following subjects:

1. Working environment
2. Traffic
3. Dangerous jobs
4. Other activities
5. Occupational health
6. Implementation and use

The checklist items include e.g. general work methods, work phases and items, and abstract dangers or concerns.

In the context of the definitions made in the RM protocol for transport infrastructure projects (Liikennevirasto 2015), the safety risk identification procedure combines a group of essential tools of risk management.

4. RM in railway planning (Liikennevirasto 2010)

The guideline describes in detail the policy, process, objectives, principles, methods and practices of both RM and single risk assessments. The included RM tools follow the structure of the Safety risk identification procedure for infrastructure projects (Liikennevirasto 2012), in order to achieve compatibility between methods, although SWOT-analysis is also included for use in the preliminary planning phase.

The hazard checklists cover the following subjects:

1. Risks relating to the execution of the project
2. Process risks [read: project management risks]
3. Planning risks
4. Environmental risks
5. Risks of construction and maintenance phases

While the titles appear universal, the lists do not in practice apply to waterway projects. The list number 2 makes an exception, and is applicable, though it does contain some railway vocabulary.

5. Risks in road care service agreements (Tiehallinto 2009)

The guideline handles risk management principles and practices in planning, tendering and execution of road care service agreements. This includes detailed process descriptions of both the RM process and the risk assessments, descriptions of the required documents, and some guidance for a risk-informed tendering process.

The included RM tools follow the structure of the Safety risk identification procedure for infrastructure projects (Liikennevirasto 2012).

The hazard checklists cover the planning, tendering and execution of service agreements thoroughly, but on a very general level, and thus they could be useful in waterway related service agreement tendering processes as well.

6. The FTA process management system

The FTA process management system describes all the processes in the FTA. The processes are described hierarchically. The top level consists of the main processes of the organization, which in turn consist of a number of sub-processes. Each of these processes is appointed to an owner, which correspond or should correspond to the management hierarchy of the FTA.

The risks to the main process match the strategic risks of the FTA, while the risks to the sub-processes correspond to the process risks, which are defined in the FTA RM Principles (2016d).

The process management system is under development, and the process descriptions are not complete.

7. Safety and RM register (TURI)

The safety and RM register of the FTA is a system for containing the information of the safety and project risks, and the detected safety anomalies in FTA projects and on the rail network.

The risk register includes fields for risk description and consequence, risk treatment and its follow-up, and risk level before and after the treatment, which is based on the semi-qualitative FTA 5x5 risk matrix.

The full-scale commissioning of the system in all FTA projects was underway during the writing of this thesis, and was bound to finish by the end of year 2016.

8. The FTA internal tender and project management guidelines and contract forms

The internal tender and project management guidelines and contract forms can be found in an FTA internal wiki-like-environment – the term "project management toolbox" might describe it well.

In terms of waterway project RM, the toolbox provides an example of a risk management plan, contract forms including safety risk management tools, and guidelines for tendering and management of each project phase.

The constructs

A6.1 Waterway project RM process descriptions

The processes are described on a general level in Section 4.4.1.

LEGEND

RISK ASSESSMENT

Project risk assessment is conducted in three phases: 1) Project management risk assessment, 2) Project risk assessment, and 3) Safety and health risk assessment.

Project management risk and project risk assessment is conducted with the tools provided as appendixes to this framework. The safety and health risk assessment is conducted with the INFRA risk map, a.k.a. the Safety risk identification method, and it's result should be accounted for in the compulsory safety documents in addition to the safety risk management plan.

Risk assessment consists of risk identification, risk analysis and risk treatment planning. Risks should always be evaluated in regard to the project objectives, allowing for positive risk. The risk assessment procedure is described in more detail as a part of the attached tools.

Risk assessment should be planned with additional thoroughness, should a) the project include specific requirements for risk management, b) the project be exceptionally demanding, or c) the project include risks with hazardous consequences, which are challenging to analyse, or demanding or expensive to remarkably diminish. In these cases it may be necessary to use specific methodology along with a risk management professional.

RISK MANAGEMENT ACTIVITY

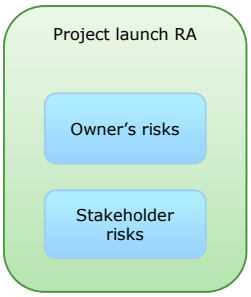
The figure is used to describe other risk management activity than risk assessments.

RECOGNISED RISKS

The figure is used to describe the identified and analysed project risks, which are described in the risk management plan.

A part of the project's risks can be forwarded to the service provider through contracts. Risks should usually be carried by the stakeholders, which are in the best position to carry and manage them.

CONSTRUCTION



PROJECT LAUNCH RISK ASSESSMENT

Before beginning the risk management process, the risk approach for the project should be coarsely planned; can this process description be used as such?

During the project launch RA the risk management plan is created or updated from the following viewpoints:

1. Project management risks – special weight on the risks related to tendering; the other risks can be dealt with in detail later.
2. Project risks
3. Safety and health risks

The client should ensure the following when appropriate while planning risk management:

- The leftover risk information from the planning phase have been exploited
- The interfaces of the project with the FTA process level and main process level risks have been evaluated, and the risk treatments are accordingly planned.
- All risk types have been assessed
- The risks have been compared with the risks identified in similar projects along with their anomalies
- Responsibilities for the risks' treatments have been initially planned in order for the risks to be considered in the tender process
- The risks affecting the owner have an adequate treatment plan, and the actions are sufficient in relation to an acceptable risk level

ALLOCATION OF RISKS TO SERVICE PROVIDERS THROUGH TENDER PROCESS

The owner should take the following into account while preparing tender documents:

- Transferring the chosen risks to the service providers
- The possibility to require the service providers to plan risk response to the risks appointed to them, and thus ensure adequate understanding about the risk. The identified risks can be given to the service providers for them to analyse, which provokes discussion on risk.
- Tender process risks

CONSTRUCTION LAUNCH RISK ASSESSMENT

The risk management plan is updated.

The following things should be ensured as appropriate while planning the construction phase RM:

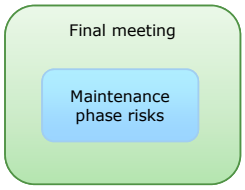
- The possible changes to the FTA process level and main process level risks have been accounted for
- All risk types have been assessed
- The risks have been compared with the risks identified in similar projects by the service provider
- Risk owners and risk treatment responsibilities have been planned
- The risks affecting the owner have an adequate treatment plan, and the actions are sufficient in relation to the acceptable risk level

RISK MANAGEMENT REVIEW

The regularly kept reviews ensure the flow of knowledge between the stakeholders, while evaluating:

1. The changes in identified risks due to successful treatment of or other reasons
2. Whether the treatment plan is up-to-date
3. Evolution of new risks and changes in the previously identified risks

Risks and their development should be kept on the agenda of construction site and planning meetings, and the third parties should be informed of risks when required.

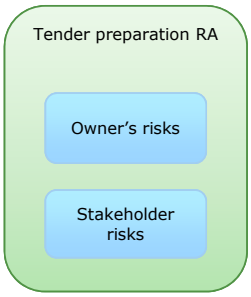


FINAL MEETING

In the final meeting the following is stated:

1. The risks continuing on to the maintenance phase
2. The realised risks, their effects to the project, the remediating actions done, and the lessons learned in terms of RM
3. Safety anomalies during the project
4. The location of the project RM documents in the FTA information systems along with the RM documents of other finished projects, in order for them to be exploited in the projects to come
5. Feedback from the RM methods and processes

MAINTENANCE / USE AND CARE: SERVICE AGREEMENTS



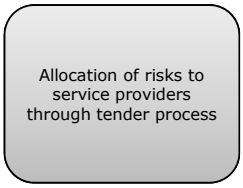
TENDER PREPARATION RISK ASSESSMENT

Before beginning the risk assessment process, the risk management approach for the tendering process should be updated or planned. Special value should be given to the risk management in this phase, when the division of risks between the client and the service provider can be affected.

The risk assessment should be done at latest, when the next year's tender process is being prepared. The previous projects should be learnt from as much as possible.

The client should ensure the following when appropriate while planning risk management:

- The leftover risk information from the previous and parallel projects and from possible construction projects has been exploited, along with the anomaly reports
- The interfaces of the project with the FTA process level and main process level risks have been evaluated, and the risk treatments are accordingly planned.
- All risk types have been assessed from the tender process's point of view.
- Responsibilities for the risk treatments have been initially planned, and they are sufficient in relation to an acceptable risk level



ALLOCATION OF RISKS TO SERVICE PROVIDERS THROUGH TENDER PROCESS

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- Transferring the chosen risks to the service providers
- The possibility to require the service providers to plan risk response to the risks appointed to them, and thus ensure adequate understanding about the risk. The identified risks can be given to the service providers for them to analyse, which provokes discussion on risk.
- Tender process risks

AGREEMENT PERIOD LAUNCH RA

The risk management plan is updated.

The following things should be ensured as appropriate while planning the construction phase RM:

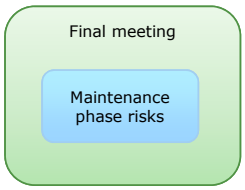
- The possible changes to the FTA process level and main process level risks have been accounted for
- All risk types have been assessed
- The risks have been compared with the risks identified in similar projects by the service provider
- Risk owners and risk treatment responsibilities have been planned
- The risks affecting the owner have an adequate treatment plan, and the actions are sufficient in relation to the acceptable risk level

RISK MANAGEMENT REVIEW

The regularly kept reviews ensure the flow of knowledge between the stakeholders, while evaluating:

1. The changes in identified risks due to successful treatment of or other reasons
2. Whether the treatment plan is up-to-date
3. Evolution of new risks and changes in the previously identified risks

Risks and their development should be kept on the agenda of construction site and planning meetings, and the third parties should be informed of risks when required.



FINAL MEETING

In the final meeting the following is stated:

1. The risks continuing on to the maintenance phase
2. The realised risks, their effects to the project, the remediating actions done, and the lessons learned in terms of RM
3. Safety anomalies during the project
4. The location of the project RM documents in the FTA information systems along with the RM documents of other finished projects, in order for them to be exploited in the projects to come
5. Feedback from the RM methods and processes

MAINTENANCE / UPKEEP

UPKEEP RISK MANAGEMENT

The upkeep projects are very variable in terms of time, scale and other attributes. It is relevant for the RM approach and the project features to be in line with each other.

The risk management methods are preliminarily divided into three groups below based on the size of project:

- SMALL: RM can be dealt with through e-mail or phone in projects worth less than 100 000 € or with duration of less than 1 month
- MEDIUM: Projects worth less than 500 000 € should include RM methodology as parts of construction site and other meetings
- LARGE: Projects worth more than 500 000 € should manage risks in full-scale RM meetings (e.g. before construction site meeteings)

The RM approach should always be in accordance with the project demandingness, uniqueness and circumstances. The project-specific risks should always be identified.

Especially in small projects, involving repetitive and well forecastable jobs, the RA can be done using only system description. In this case the project is divided into single jobs and work phases, and each is pursued for risks, or factors causing uncertainty.

The risks should be written down in small projects as well – shortly but unambiguously, e.g. using the first three columns of the risk management form. If a risk clearly surpasses the risk appetite before its dedicated treatment, all the columns should be filled for that risk.

In large projects the RM methodology approaches the methodology of a construction project, which are described above.

When a project is terminated, a short feedback form should be sent to the contractor about the RM procedures in the project. This can be a part of a larger feedback survey.

A6.2 Hazard checklists

1. Project management checklist

1.1 Contracting and resposibilities

1 Assignment contents
2 Resposibilities and their allocation
3 Contract interfaces
4 Changes/additions in contracts
5 Warranties, insurances
6 Conflict resolution
7 Work quality defects
8 Quality assurance
9 Responsibilities for plans and their quality

1.2 Guidelines and regulations

1 Technical guidelines and regulations
2 Safety regulations
3 Environmental regulations
4 Other regulations
5 Regulation changes during the project (laws, norms, EU-enactments)
6 Application of guidelines and regulations
7 Client's guidelines
8 Other guidelines

1.3 Society

1 Acceptability achievement
2 Interaction and informing
3 Public image
4 Political cycles
5 Government economy

1.4 Resources and know-how

1 Client's resources
2 Service provider resources
3 Special know-how

1.5 Permits

1. Acknowledging permit requirements
2. Conditions for permits
3. Permit schedules
4. Permit complaints
5. Changing requirements of permit authorities
6. Permit terms
7. Authority resources

1.6 Schedule

1. Authority processing times
2. Prolonging of planning / construction
3. Realism of schedules
4. Critical points of schedules
5. Implementation schedules
6. Effects of other projects
7. Special schedules

1.7 Cooperation and information flow

1. Municipalities
2. Authorities
3. Harbors
4. Pilotage
5. Other organizations
6. Inahbitants, citizens
7. Service providers
8. Service users
9. Other traffic forms
10. Construction site atmosphere

1.8 Finance

1. Project estimate and its structure
2. Market situation
3. Government funding
4. Municipality funding
5. Other funding (ppp, companies, EU)
6. Contracting prices, market situation
7. Budgets, finance monitoring
8. Plan quality and research accuracy

1.9 Tendering

1 Contract terms
2 Source information
3 Bidding, tender process
4 The amount of offers
5 Complaint process
6 Contract documents
7 Interaction during the bidding process

2. Construction checklist

2.1 Dredging and quarrying

1 Mass balance
2 Dredging technique
3 Quarrying and intermediate storing of explosives
4 Blasting (danger to outsiders)
5 Scanning
6 Working order
7 Storage and loading
8 Relocation of lines and devices
9 Braking of safety devices

2.2 Fills

1 Contaminated soil
2 Mass balance
3 Fill solutions and capacity

2.3 Civil engineering structures

1 Piers and erosion slabs
2 Bridges
3 Harbors
4 Canals
5 Locks
6 Embankments, mass stability
7 User requirements
8 Erosion

2.4 Navigation marks

1 Fixed navigation marks
2 Buoyant navigation marks
3 Temporary navigation mark arrangements
4 Navigation signs
5 Light and energy device work
6 Informing from the work
7 Care responsibilities

2.5 Environment

1 Contaminated soil
2 Spreading of contaminated sediments and nutrients
3 Cloudiness of surface waters
4 Oil leaks ashore and to water
5 Solvent, paint, etc. substance leaks
6 Noise in the vicinity of housing or environmental protection areas
7 The effect of the noise to fishes
8 Effects to fishing industry
9 Work in the vicinity of nesting areas during nesting season

2.6 Waterborne traffic

1 Communication and informing
2 Communication during emergencies
3 Traffic and construction works coordination
4 Non-pilotaged traffic, pilotage service providers and shipbrokers
5 Maintenance traffic external to the project
6 Construction site traffic, coordination of multiple contracts
7 Yachting, fishing
8 Reacting to changing markings

2.7 Weather

1 Exposure to wind, swell
2 Ice circumstances, duration of open water season
3 Weather conditions during lifting
4 Blasting works during lightning

2.8 Technical matters

1 Special solutions
2 Water level measurement, coordinate systems
3 Satellite positioning
4 Equipment failure
5 Anchoring
6 Water flow

2.9 Other

1 Diving work
2 Surveys
3 Documentation of changes
4 Sea-lane enactment

3. Maintenance checklist

USE AND CARE

3.1 Fixed navigation marks

1 Light and energy device work
2 Sector work
3 Radar beacon work
4 Clearing; environment care
5 Risk caused by structural type
6 Work at a height, and climbing
7 Onshoring

3.2 Buoyant navigation marks

1 Light and energy device work
2 Anchoring
3 Pre-tensioning
4 Lifting

3.3 Other navigation mark work

1	Navigation mark condition monitoring
2	Navigation mark remote control
3	Navigation mark installation, relocation, modification and removal
4	Temporary navigation mark arrangements
5	Navigation signs
6	Care work
7	Diving work
8	Electrical work
9	Hot work operation
10	Surface treatments

3.4 Canals

1	Condition monitoring
2	Remote control
3	Lighting
4	Clearing; environment care
5	Shaft work
6	Diving work
7	Electrical work
8	Building of maintenance dams
9	Winter traffic assistance

UPKEEP

3.3 Need for separate risk identification:

1	Planning
2	Keeping of register
3	Sea-lane enactment, see a separate list of enactment documents

3.4 Waterways and navigation marks

1	Monitoring of civil engineering structure condition (lighthouses, piers, cardinal marks etc.)
2	Renovation and construction
3	Dredging, see "Construction" checklist
4	Fixed navigation marks
5	Buoyant navigation marks
6	Temporary navigation mark arrangements
7	Navigation mark installation, relocation, modification and removal
8	Anchoring
9	Navigation signs

10 Surface treatments
11 Diving works

3.5 Canals

1 Renovation and construction
2 Surface treatments
3 Diving works

3.6 Investigations

1 Sounding, laser and multibeam
2 Scanning
3 Ground surveying and boring

COMMON FACTORS

3.7 Environment

1 Oil leaks
2 Solvent, paint, etc. substance leaks
3 Noise in the vicinity of housing or environmental protection areas
4 Work in the vicinity of nesting areas during nesting season
5 Bird nests in navigation marks
6 Bird and animal excrements
7 Effects to fishing industry
8 Water flow

3.8 Waterborne traffic

1 Communication and informing
2 Communication during emergencies
3 Traffic and construction works coordination
4 Other waterborne traffic
5 Reacting to changing markings
6 Loss of steerability, anchor failure, ship handling

3.9 Weather

1 Exposure to wind, swell
2 Ice circumstances, duration of open water season
3 Weather conditions during lifting

4 Frost, cold working conditions
5 Water level alternation

3.10 Technical matters

1 Information traffic (incl. satellite positioning)
2 Equipment failure
3 Anchoring
4 Water level measurement, coordinate systems
5 Sea warnings and navigation mark error messages

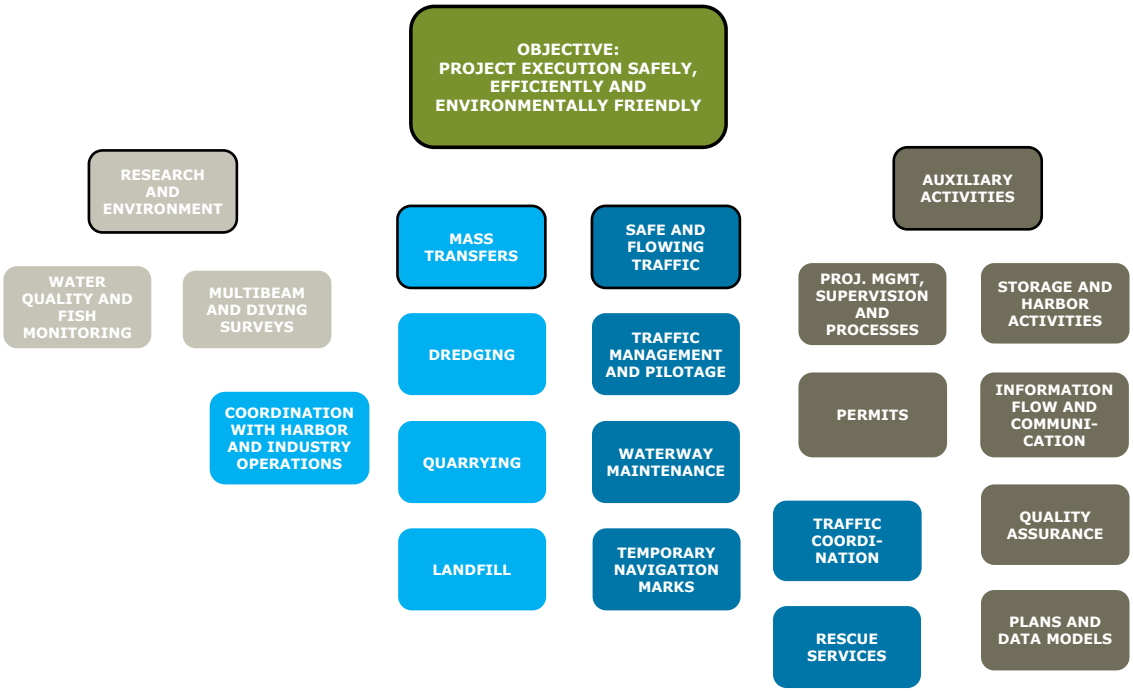
3.11 Other

1 Documentation of changes
2 Logging of actions
3 Care responsibilities
4 Haste
5 Common worksites
6 Storage and harbor operations

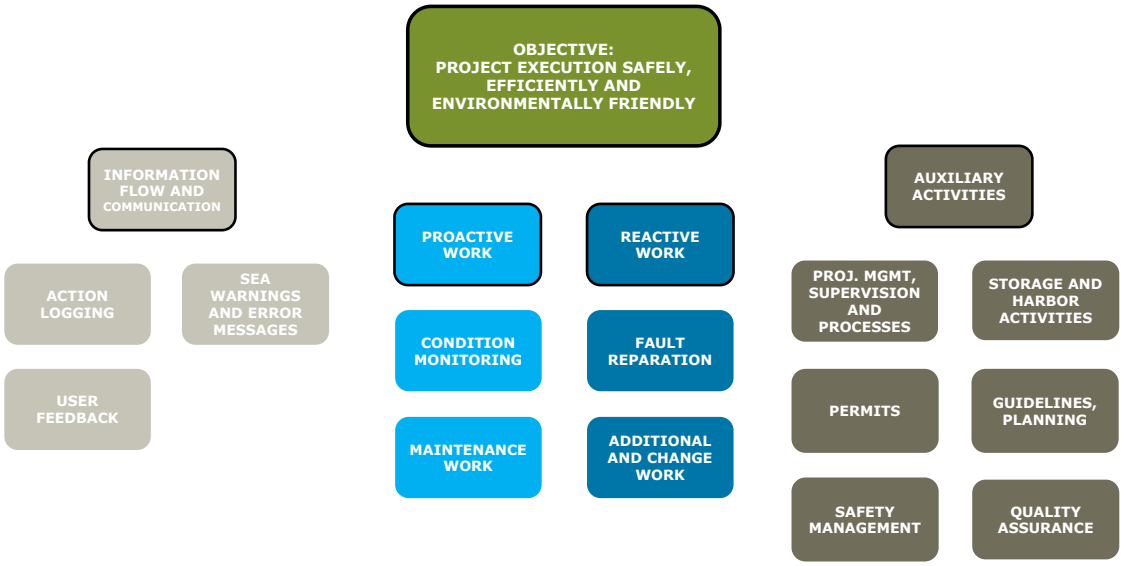
A6.3 Model for establishing a project's RM process context

The model and its use are demonstrated through the three examples from the three case studies. Two of the case examples are provided below, and the third can be found in Section 4.4.5.

CASE A: DREDGING PROJECT
RM PROCESS CONTEXT



CASE B: CARE PROJECT
RM PROCESS CONTEXT



A6.4 Modified risk matrix

The matrix includes the modifications related to the RM constructs Opportunity management as a part of RM and the Modified FTA risk analysis process.

Risk level analysis

Risk consequence
- What would usually follow from the realization of the risk
- What would be the consequence in the best/worst case
- Project specific

	Negative consequence seriousness / magnitude					Positive consequence magnitude				
Consequence type	1 No consequences	2 Slight	3 Serious/remarkable	4 Big	5 Very big	5 Very big	4 Big	3 Remarkable	2 Slight	1 No consequences
Personal injury	No injured	Slight injuries, sick leave less than 14 days	Serious injuries, sick leave more than 14 days	Deaths	Several deaths			Zero injuries - usability depends on project		
Financial effect	No property or business damage	Financial effect Less than 2000 €	Financial effect 2 000 - 1 000 000 €	Financial effect 1 000 000 - 5 000 000 €	Financial effect More than 5 000 000 €	Financial effect More than 5 000 000 €	Financial effect 1 000 000 - 5 000 000 €	Financial effect 2 000 - 1 000 000 €	Financial effect Less than 2000 €	No property or business damage
Operational effect	No effect to planning or contract schedule No claims	Hinders planning or contractor work Small claims	Impedes planning or contractor work Serious claims	A month's delay in the project schedule Big claims	Several months' delay in schedule Very big claims	Several months' reducement in the project schedule Very big improvement in quality	A month's reducement in the project schedule Big improvement in quality	Promotes planning or contractor work Remarkable improvement in quality	Slightly promotes planning or contractor work Slight improvement in quality	No effect to planning or contract schedule No quality effect
Traffic effect	No effect on traffic	Slight traffic impediment	Serious traffic impediment	Big traffic impediment	Very big traffic impediment	Very big traffic benefits	Big traffic benefits	Remarkable traffic benefits	Slight traffic benefits	No effect on traffic
Environmental effect	No environmental damage	Slight environmental damage, minor impediments, easily repairable	Serious environmental damage, moderate impediments, repairable	Big environmental damage, moderate and vast impediments, repairable	Very big environmental damage, moderate and vast long-term impediments, hardly repairable	Very big ecosystem-level environmental benefit	Big environmental benefits	Remarkable environmental benefits	Slight environmental benefits	No effect on environment

Risk probability
- How often is the realization possible
- How often does the risk realize

Risk probability Literate description	Percentual probabilities
5 Very common Appears atleast 10 times a year	80-100%
4 Common Appears atleast once a year	60-80%
3 Occasional Appears atleast once in 10 years or once during the project execution	40-60%
2 Rare Appears atleast once in 100 years or once during the product's lifetime	20-40%
1 Very rare Appear less than once in a 100 years Theoretical, is not known to have occurred during construction or use	0-20%

Event frequency	No consequences	Slight	Serious/remarkable	Big	Very big	Very big	Big	Remarkable	Slight	No consequences
Very common	Slight	Moderate	Serious	Unbareable	Unbareable	Very remarkable	Very remarkable	Remarkable	Moderate	Slight
Common	Negligible	Slight	Moderate	Serious	Unbareable	Very remarkable	Remarkable	Moderate	Slight	Negligible
Occasional	Negligible	Slight	Moderate	Moderate	Serious	Remarkable	Moderate	Moderate	Slight	Negligible
Rare	Negligible	Negligible	Slight	Moderate	Serious	Remarkable	Moderate	Slight	Negligible	Negligible
Very rare	Negligible	Negligible	Negligible	Slight	Moderate	Kohtalainen	Slight	Negligible	Negligible	Negligible

Treatment classification		
V class	V+ class	Immediate action
IV class	IV+ class	Action in the current project phase
III class	III+ class	Actions must be planned
II class	II+ class	To be followed
I class	I+ class	No treatment needed

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